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TECHNICAL REPORT NO. 66-102

OPERATION OF UBSO
Quarterly Report No. 2, Project VT/6705
1 August through 31 October 1966

TELEDYNE INDUSTRIES
GEOTECH DIVISION
GARLAND TEXAS

TECHNICAL REPORT NO. 66-102

OPERATION OF UBSO
Quarterly Report No. 2, Project VT/6705
1 August through 31 October 1966

Sponsored by

Advanced Research Projects Agency
Nuclear Test Detection Office
ARPA Order No. 624

TELEDYNE INDUSTRIES
GEOTECH DIVISION
3401 Shiloh Road
Garland, Texas

17 November 1966

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ABSTRACT

This report describes the operation of the Uinta Basin Seismological Observatory (UBSO) from 1 August through 31 October 1966. Modifications and additions to the observatory instrumentation are described, and tests to improve the operation of the observatory are reported. Also discussed is the status of special investigations designed to evaluate and improve the detection capability of the observatory.

OPERATION OF UBSO

1. INTRODUCTION

1.1 AUTHORITY

The work described in this report was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center (AFTAC) under Contract AF 33(657)-16563. The Statement of Work for this contract is shown in appendix 1.

1.2 HISTORY

UBSO was constructed under Contract AF 33(657)-7185. Site selection and noise surveys were accomplished by Teledyne Industries, Geotech Division, (formerly The Geotechnical Corporation); the final decision on the observatory location was made by AFTAC. Texas Instruments, Incorporated (TI) was responsible for the construction of all physical facilities.

Contract AF 33(600)-43486, issued to TI, contained the authority for equipping and operating UBSO. The instrumentation was supplied by Geotech and was installed under the direction of Geotech personnel under subcontract to TI. TI operated the observatory from November 1962 until 1 July 1963. Under Projects VT/1124 and VT/5054, Contract AF 33(657)-12373, Geotech operated UBSO from 1 July 1963 through 30 April 1966.

2. OPERATION OF UBSO

2.1 GENERAL

Data are recorded at UBSO on a 24-hour basis. The observatory is normally manned 8 to 10 hours a day, 5 days a week. On weekends and holidays, a skeleton crew mans the observatory 8 hours a day; however, additional personnel are on call in case of an emergency.

2.2 SEISMOGRAPH OPERATING PARAMETERS

2.2.1 Standard Seismographs

The operating parameters and the tolerances for the standard observatory seismographs are shown in table 1. These parameters are reset, as necessary, when the frequency response of a seismograph is found to be out of tolerance. The frequency response norms and their respective tolerances are shown in table 2. The frequency responses of the UBSO seismographs, as normally operated, are shown in figure 1.

2.2.2 Filters for Multi-Channel Array Processors (MAP)

All MAP data utilize a band-pass filter with the following settings: high-cut frequency of 3 cps at 3 dB per octave cutoff rate, and a low-cut frequency of 1 cps at 12 dB per octave cutoff rate.

2.2.3 Filters for Array Summations

Summations of the 10-element surface array and the shallow-buried array are each filtered by a band-pass filter with the following settings: high-cut frequency of 3 cps and low-cut frequency of 0.8 cps, both at a cutoff rate of 18 dB per octave. The six-elements of the vertical array are summed and two filtered outputs are recorded in Data Group 5056. One of the outputs (ΣDH) is filtered at 5 and 0.375 cps, both at a rate of 24 dB per octave; the second output (ΣDHF) is filtered at a high-cut frequency of 3 cps and a rate of 24 dB per octave, and a low-cut frequency of 0.75 cps and a rate of 36 dB per octave.

2.3 DATA CHANNEL ASSIGNMENTS

Several recording format changes were made during this reporting period. Data Group 5046 was established on 28 July, and test recordings of elements of vertical array began on 16 September. This Data Group was changed on 8 September to Data Group 5056. Data Group 5054, MAP II, was initiated on 27 September, providing for additional MAP recordings. The current data channel assignments for all UBSO data groups are shown in table 3. The key to the designators used in the data channel assignments is given in table 4.

Table 1. Operating parameters and tolerances of seismographs at UBSO

Seismograph		Seismometer		Operating parameters and tolerances					Filter settings	
System	Comp	Type	Model	T_s	λ_s	T_g	λ_g	σ^2	Bandpass at 3 dB cutoff (sec)	Cut off rate at SP side (dB/oct)
SP	Z and H	Johnson-Matheson	7515, 6480	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.03	0.1-100	12
SP	SZ	Geotech	18300	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.053	0.1-100	12
SP	Z	UA Benioff	1051	1.0 ±5%	1.0	0.083 ±5%	≈1.4	1.0	-	-
IB	Z	Melton	10012	2.5 ±5%	0.65 ±5%	0.64 ±5%	1.2 ±5%	0.018	0.05-100	12
IB	H	Geotech	8700B	2.5 ±5%	0.65 ±5%	0.64 ±5%	1.2 ±5%	0.001	0.05-100	12
BB	Z	Geotech	7505	12.5 ±5%	0.485 ±5%	0.64 ±5%	9.0 ±5%	0.0007	0.05-100	12
BB	H	Geotech	8700A	12.5 ±5%	0.485	0.64 ±5%	9.0 ±5%	0.0007	0.05-100	12
LP	Z	Geotech	7505A	20.0 ±5%	0.74 ±5%	110 ±10%	0.85 ±10%	0.63	25-1000	12
LP	H	Geotech	8700A	20.0 ±5%	0.74 ±5%	110 ±10%	0.85 ±10%	0.63	25-1000	12

KEY

SP	Short period	T_s	Seismometer free period (sec)
IB	Intermediate band (currently inactive)	T_g	Galvanometer free period (sec)
BB	Broad band	λ_s	Seismometer damping constant
LP	Long period	λ_g	Galvanometer damping constant
UA	Unamplified (i.e., earth powered)	σ^2	Coupling coefficient

Table 2. Calibration norms and operating tolerances for frequency responses of the standard seismographs at UBSO

SP Vertical 18300 and SP Johnson-Matheson Vertical and Horizontal

f (cps)	T (sec)	R. M.	A. T. (±%)
0.2	5.0	0.0113	10
0.4	2.5	0.0950	7.5
0.8	1.25	0.685	5
1.0	1.0	1.0	-
1.5	0.67	1.52	5
2.0	0.5	1.90	5
3.0	0.33	2.12	7.5
4.0	0.25	1.87	12
6.0	0.167	1.15	20
8.0	0.125		
10.0	0.100		

LP Vertical and Horizontal [c]

f (cps)	T (sec)	R. M.	A. T. (±%)
0.01	100	0.246	20
0.0125	80	0.377	20
0.0167	60	0.589	15
0.02	50	0.745	15
0.025	40	0.899	10
0.033	30	1.06	5
0.04	25	1.0	-
0.05	20	0.822	5
0.0667	15	0.506	10
0.10	10	0.173	20
0.143	7	b	a

IB Vertical and Horizontal

f (cps)	T (sec)	R. M.	A. T. (±%)
0.1	10.0	0.0090	25
0.2	5.0	0.068	20
0.3	3.3	0.25	15
0.4	2.5	0.46	10
0.5	2.0	0.64	5
0.7	1.43	0.86	5
1.0	1.0	1.0	-
1.5	0.67	1.04	5
2.0	0.5	1.0	10
3.0	0.33	0.89	15
5.0	0.2	0.66	20

BB Vertical and Horizontal

f (cps)	T (sec)	R. M.	A. T. (±%)
0.04	25.0	0.104	20
0.06	16.7	0.350	20
0.08	12.5	0.775	15
0.1	10.0	0.950	10
0.2	5.0	1.0	5
0.4	2.5	1.0	5
0.8	1.25	1.0	-
1.6	0.625	1.0	5
3.2	0.312	1.0	10
6.4	0.156	0.980	15

KEY

R. M. Relative magnification
A. T. Amplitude tolerance
a Tolerance not established in the period
b Measurements not reliable due to interference from microseismic background noise
c These norms and tolerances, apply to the broad-response long-period system (LP1).

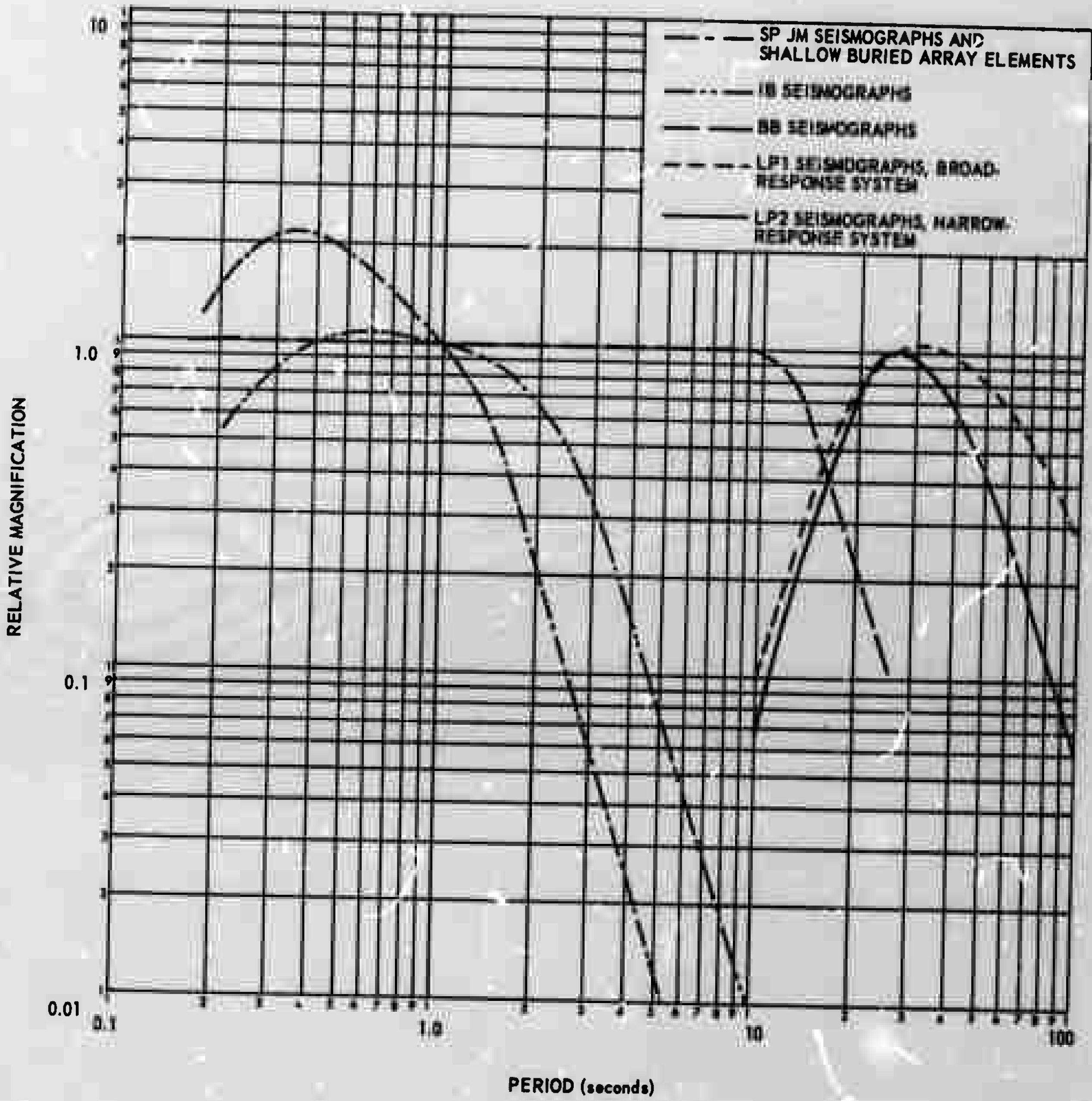

Figure 1. Normalized response characteristics of the standard seismographs at UBSO

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2.4 SHIPMENT OF DATA TO THE SEISMIC DATA LABORATORY (SDL)

Magnetic-tape seismograms are shipped to SDL with the regular Long Range Seismic Measurements (LRSM) Program data shipment about 15 days after the end of the month during which they were recorded. The magnetic-tape seismograms recorded at UBSO through 30 September have been shipped to SDL.

All 16-millimeter film seismograms recorded at UBSO through 31 March were sent to SDL. More recent films are currently held in Garland for special studies.

2.5 QUALITY CONTROL

2.5.1 Quality Control of 16-Millimeter Film Seismograms

Quality control checks of randomly selected runs of 16-millimeter film from the shallow-buried array, the surface array, and the long-period seismograph, and the associated operating logs are made in Garland. Items that are routinely checked by the quality control analyst include:

a. Film boxes - neatness and completeness of box markings;

b. Develocorder logs - completeness, accuracy, and legibility of logs;

c. Film;

(1) Quality of the overall appearance of the record (for example, trace spacing and trace intensity);

(2) Quality of film processing;

d. Analysis - completeness, legibility, and accuracy of the analysis sheets.

Results of these evaluations are sent to the observatory for review and comment by the observatory personnel.

Table 3. Data channel assignments and normal operating magnifications at UBSO

DEVELOCORDERS

Fast speed, 30mm/minute

Data group 5044 — SP primary

Channel	Trace	Mag
1	V	17K
2	SZ1	600K
3	SZ3	600K
4	SZ5	600K
5	SZ2	600K
6	SZ4	600K
7	SZ6	600K
8	SZ7	600K
9	SZ8	600K
10	SZ9	600K
11	ΣSSF	6000K
12	ΣSS	1500K
13	SZ10	600K
14	NSP	600K
15	ESP	600K
16	WWV	- -

Data group 5050

Channel	Trace	Mag
1	Z10L	60K
2	NSPL	60K
3	ESPL	60K
4	Z1	600K
5	Z3	600K
6	Z5	600K
7	ΣSF	6000K
8	ΣS	1500K
9	Z2	600K
10	Z4	600K
11	Z6	600K
12	Z7	600K
13	Z8	600K
14	Z9	600K
15	Z10	600K
16	WWV	- -

Data group 5056

Channel	Trace	Mag
1	V	1.5K
2	MS1	0.76 μb/mm
3	MS2	- -
4	DH6	1000K
5	DH5	1000K
6	DH4	1000K
7	DH3	1000K
8	DH2	1000K
9	DH1	1000K
10	ΣDHF	Testing
11	ΣDH	Testing
12	SZ8	600K
13	USO-SP	
14	USO time	
15	WI	3 mph = 1 mm; S = 0/8 mm (E = 6 mm)
16	WWV	

Data group 5061 — Map 1

Channel	Trace	Mag
1	Test	- -
2	MCF4	3000K
3	MCF1	3000K
4	MCF3	3000K
5	BSS1	2800K
6	BSS2	2800K
7	BSS3	2800K
8	BSS4	2800K
9	BSS5	2800K
10	BSS6	2800K
11	ΣSBS	2800K
12	Test	- -

Data group 5054 — Map 2

Channel	Trace	Mag
1	Test	- -
2	MCF11	3000K
3	MCF12	Testing
4	MCF13	Testing
5	MCF14	Testing
6	MCF15	Testing
7	MCF16	Testing
8	MCF17	Testing
9	BSSV1	Testing
10	BSSV2	Testing
11	BSSV3	Testing
12	BSSV4	Testing
13	BSSV5	Testing
14	BSSV6	Testing
15	ΣDVS	Testing
16	Test	- -

Slow speed, 3 mm/mioute

Data group 5048

Channel	Trace	Mag
1	W1	3 mph = 1 mm; S = 0/8 mm (E = 6 mm)
2	SZ2	300K
3	ZLP1	25K
4	NLP1	25K
5	ELP1	25K
6	NLPs	20K
7	ZLP2	100K
8	NLP2	100K
9	ELP2	100K
10	ML1	0.73 μb/mm
11	ML2	0.73 μb/mm
12	USO-LP	- -
13	ZBB	1.0K
14	NBB	1.0K
15	EBB	1.0K
16	WWV	- -

MAGNETIC-TAPE RECORDERS

Data group 5021 — No. 1

Channel	Trace
1	TCMDG
2	Z1
3	Z2
4	Z3
5	Z4
6	Z5
7	Comp
8	Z6
9	Z7
10	Z8
11	Z9
12	Z10
13	ΣS
14	WWV & Voice

Data group 5023 — No. 2

Channel	Trace
1	TCMDG
2	ZBB
3	NBB
4	EBB
5	NSP
6	ESP
7	Comp
8	ZLP1
9	NLP1
10	ELP1
11	ZLP2
12	NLP2
13	ELP2
14	WWV & Voice

Data group 5025 — No. 3

Channel	Trace
1	TCMDG
2	SZ1
3	SZ2
4	SZ3
5	SZ4
6	SZ5
7	Comp
8	SZ6
9	SZ7
10	SZ8
11	SZ9
12	SZ10
13	ΣSS
14	WWV & Voice

Table 4. Key to the designations used in the data format assignments at UBSO

Z	Amplified vertical short-period seismograph from a site identified by a suffix number
ZLP1	Vertical long-period seismograph, broad response
ZLP2	Vertical long-period seismograph, narrow response
ZBB	Vertical broad-band seismograph
V	Unamplified vertical short-period seismograph
ΣS	Summation of Z1 through Z10
ΣSF	ΣS filtered
ΣSS	Summation of SZ1 through SZ10
ΣSSF	ΣSS filtered
NSP	Amplified north-south short-period seismograph
NLP1	North-south long-period seismograph, broad response
NLP2	North-south long-period seismograph, narrow response
NLP_s	North-south long-period seismograph, broad response (operated in surface tank)
NBB	North-south broad-band seismograph
ESP	Amplified east-west short-period seismograph
ELP1	East-west long-period seismograph, broad response
ELP2	East-west long-period seismograph, narrow response
EBB	East-west broad-band seismograph
WWV	Radio time - (WWV, STS, and voice on tape)
ML1	Long-period microbarograph - monitors pressure inside LP vault
ML2	Long-period microbarograph - monitors pressure outside LP vault
MS1	Short-period microbarograph - monitors pressure inside LP vault
MS2	Short-period microbarograph - monitors pressure outside LP vault
DH6	Vertical array element @ 3907 feet
DH5	Vertical array element @ 4901 feet
USOLP	Unmanned seismological observatory long-period
W1	Anemometer - wind speed & direction
Test	Test instrumentation
Comp	Compensation
Mag	Magnification (see note)
TCMDG	Time code management data group
MCF4	Multi-channel filtering designed to emphasize recording of vertically incident P waves and reject road noise (modified MCF1)
MCF2	Multi-channel filtering designed to emphasize recording of vertically incident P waves and reject dominant noise with additional filtering to reduce amplitude of long-period microseisms
MCF3	Multi-channel filtering designed to emphasize recording of P waves with apparent horizontal velocity of 8.1 km/sec or greater and reject dominant noise
BSS1	Beam steering summation to emphasize 8.1 km/sec wave arrivals from 0° azimuth (N)
BSS2	Beam steering summation to emphasize 8.1 km/sec wave arrivals from 60° azimuth (N60E)
BSS3	Beam steering summation to emphasize 8.1 km/sec wave arrivals from 120° azimuth (S60E)
BSS4	Beam steering summation to emphasize 8.1 km/sec wave arrivals from 180° azimuth (S)
BSS5	Beam steering summation to emphasize 8.1 km/sec wave arrivals from 240° azimuth (S60W)
BSS6	Beam steering summation to emphasize 8.1 km/sec wave arrivals from 300° azimuth (N60W)
ΣSBS	Straight summation (emphasizes vertically incident P waves, simple array summation improvement of signal-to-noise ratio)
MCF11	Multi-Channel Filtering designed to emphasize recording of vertically incident P waves and reject dominant noise (subsurface array)

Table 4. Key to the designations used in the data format assignments at UBSO (Continued)

DH4	Vertical array element @ 5894 feet
DH3	Vertical array element @ 6910 feet
DH2	Vertical array element @ 7903 feet
DH1	Vertical array element @ 8895 feet
ΣDH	Summation of DH1 through DH6
ΣDHF	ΣHD filtered
USOSP	Unmanned seismological observatory short-period
MCF15	Multi-Channel Filtering designed to emphasize recording of vertically incident P waves (down-going) using 1st, 3d, and 5th deepest elements ("deghosting" - minimizes 1st arrival)
MCF16	Multi-Channel Filtering designed to emphasize recording of vertically incident P waves (up-going) using 2d, 4th, and 6th deepest elements ("deghosting" - minimizes reflection)
MCF17	Multi-Channel Filtering designed to emphasize recording of vertically incident P waves (down-going) using 2d, 4th, and 6th deepest elements ("deghosting" - minimizes 1st arrival)
BSSV1	Beam Steering Summation designed to emphasize recording of up-going vertically incident P waves
BSSV2	Beam Steering Summation designed to emphasize recording of P waves with apparent horizontal velocity of 8.1 km/sec
MCF12	Multi-Channel Filtering designed to emphasize recording of vertically incident P waves and reject dominant noise, with summation of the subsurface array as rings (1-3-5, 2-4-6, 7-8-9, 10) and the 6 elements of vertical array
MCF13	Multi-Channel Filtering designed to emphasize recording of vertically incident P waves and reject dominant noise (vertical array)
MCF14	Multi-Channel Filtering designed to emphasize recording of vertically incident P waves (up-going) using the 1st, 3d, and 5th deepest elements ("deghosting" - minimizes reflection)
BSSV3	Beam Steering Summation designed to emphasize recording of S waves with apparent horizontal velocity of 8.1 km/sec
BSSV4	Beam Steering Summation designed to emphasize recording of down-going vertically incident P waves
BSSV5	Beam Steering Summation designed to emphasize recording of down-going P waves with apparent horizontal velocity of 8.1 km/sec
BSSV6	Beam Steering Summation designed to emphasize recording of down-going S waves with apparent horizontal velocity of 8.1 km/sec
ΣDVS	Summation of six vertical array elements (with MAP Bandpass filter)

NOTE

Magnification of:
- Short-period measured at 1 cps
- Broad-band measured at 0.8 cps
- Long-period measured at 0.04 cps
- MCF measured at 1 cps
- BSS measured at 1 cps

2.5.2 Quality Control of the Magnetic-Tape Seismograms

Routine quality control checks of randomly selected magnetic-tape seismograms are made in Garland to assure that recordings meet specified standards. The following are among the items that are checked by the Quality Control Group.

a. Tape and box labeling;

b. Accuracy, completeness, and neatness of logs;

c. Adequate documentation of logs by voice comments on tape where applicable;

d. Seismograph polarity;

e. Level of calibration signals;

f. Relative phase shift between array seismographs;

g. Level of the microseismic background noise;

h. Level of the system noise;

i. PTA dc balance;

j. Oscillator alignment;

k. Quality of the recorded WWV signal where applicable;

l. Time pulse carrier;

m. Binary coded digital time marks.

2.6 SECURITY INSPECTION

Mr. William J. Robertson, Industrial Security Specialist, visited the observatory on 27 September for a facility security inspection. All observatory security procedures were found to be in order.

2.7 CABLE REPLACEMENT SURVEY

A summary of the replacement of spiral-four cable at UBSO for the interval of 1 July 1963 through 18 October 1966 was sent to the Project Officer at

his request. Only 11 reels of cable were replaced during this time (39-1/2 months).

2.8 SAFETY INSPECTION

Mr. Kenneth E. Abel, of Atwell, Vogel, and Sterling, visited UBSO on 28 September to conduct a safety inspection for workmen's compensation insurance. No dangerous conditions were found.

3. MAINTENANCE OF EQUIPMENT

3.1 TIMING SYSTEM, GEOTECH MODEL 11880

The UBSO Timing System, Geotech Model 11880, became inoperative on 15 October. A spare drive motor for the stroboscope was sent from Garland and installed. The unit was returned to service.

3.2 STORM DAMAGE

A severe lightning storm on 20 August broke the galvanometer suspension in the Z2 seismograph. This circuit was protected by AEI lightning protectors.

Four telephone poles, located approximately three-fourths mile north of UBSO, were split by lightning during a storm on 1 September. None of the observatory instrumentation was damaged by this storm, however. The only effect of the storm at the central recording building was two blown fuses in the telephone junction box.

3.3 FLOODING OF DEVELOCORDER

There have been instances of flooding of the Develocorders during the reporting period. This flooding was the result of a buildup of a heavy slime in the processor drip-tray drain, clogging the drain. Samples of the slime, taken by representatives of the Utah State Health Department, were found to be 90 percent inorganic. An evaluation of means to combat this slime build-up is currently in progress.

4. MAINTENANCE OF UBSO FACILITIES

4.1 SURFACING OF UBSO ACCESS ROAD

Surfacing of the UBSO access road was accomplished during the reporting period. Project VT/6705 paid the cost of hauling 5783 cubic yards of native asphalt (less than $4500), and the cost of spreading and rolling the asphalt was borne by the Uinta County Highway Department. All work on the road was completed by 9 September.

We expect the newly surfaced road to be a valuable asset to the observatory and to facilitate access to the station during the winter and spring months when snow and bad weather have created hazardous driving conditions in the past.

4.2 AIR CONDITIONING SYSTEM

The observatory air conditioning system has intermittently given problems and we have never considered the efficiency of the system to be adequate. Since the system was installed, routine checks and services have been furnished by a local representative. In August, when the No. 1 compressor was determined to be inoperative, a representative of Craighead Plumbing and Heating Company of Provo, Utah, was contacted to inspect and repair the system. Following is a list of problems that were found and corrected.

a. Burned-out solenoid coil in the refrigerant line of compressor No. 2.

b. Burned-out starter heater in system No. 1.

c. No. 1 system out of refrigerant due to broken weld on compressor muffler.

d. High pressure gauge on No. 1 compressor was inoperative.

e. Winterstat and check valve was stuck on system No. 1.

f. The drive belts on both compressors, the air handling fan, and the condensor fan were in very bad condition.

g. The air filters had not been serviced since the unit was installed and in addition, the filters had been installed backwards.

h. The No. 2 system was low on refrigerant.

i. The motor pulley threads were stripped on the air handling unit; the fan was being driven by only one belt.

j. The system has a very small differential between heating and cooling; however, this may be a design error. The office and shop thermostats must be set to a lower temperature (about 68°F) to maintain the desired 72°F temperature in the console area.

The winterstat and check valve assembly on system No. 1 had to be removed and the refrigerant routed directly into the condenser coils because no replacements were readily available. The repairman recommended that these valves be permanently bypassed.

From this experience we have decided that we will use the Provo representative in the future instead of the local service man because we do not believe that adequate service has been furnished in the past.

4.3 MISCELLANEOUS

The water damaged ceiling on the entry overhang of the observatory building was removed and the primed structural members were painted.

The exposed surface of the deep, long-period vault was painted. New water shields were constructed, painted, and installed around the shallow-buried array PTA vaults.

5. FIRE IN MECHANICAL ROOM OF OBSERVATORY

Fire broke out in the mechanical room of the observatory at about 7:00 p.m., MST, on Sunday, 28 August. Mr. Nils Hofmann, UBSO Station Engineer, who was working in the vicinity of the observatory after normal working hours, took rapid and effective measures to extinguish the fire. His presence of mind, undoubtedly, prevented more extensive damage to, or total loss of, the observatory.

The fire started when the high-pressure regulator, located at the gas-storage tank, failed. This allowed gas to flow into the building under high pressure. Failure of the high-pressure regulator caused the subsequent failure of the low-pressure regulators located at the boiler and the household water heater. The diaphragms of the low-pressure regulators ruptured and the escaping gas was ignited, probably by the pilot light of the household water heater. No back-up, high-pressure regulation was provided with the original UBSO

system; however, we have had a back-up system installed to preclude a recurrence of this type of trouble.

Damage resulting from the fire was limited to the mechanical room except for some superficial smoke and heat damage to the operations room at the door to the mechanical room. Much of the wiring to the air conditioning controls was burned and some of the air circulating motors were burned. No damage occurred to the seismographic instrumentation as a result of the fire.

The air conditioning was restored on a temporary basis by station personnel who wired around the burned portion of the circuit. Arrangements to restore the critical systems to normal were made within a few days. Bids for repair of all other fire damage were requested and let. Repair of fire damage is almost complete at this time.

6. EVALUATE DATA AND DETERMINE OPTIMUM OPERATIONAL CHARACTERISTICS

6.1 MODIFICATION TO UBSO INSTRUMENTATION

6.1.1 Modified Line Termination Module

On 2 August, the modified line termination module was installed in Z1 and a modified line termination module with an inductor protector was installed in Z5. No conclusive data regarding the effectiveness of either the modified line termination module or the inductor protector are available at this time.

6.1.2 Adjustable Period PTA Galvanometers

Six short-period, adjustable-period, PTA galvanometers were installed in the surface array seismographs. The galvanometers that were replaced were returned to our Garland laboratory for modification to the adjustable-period configuration.

6.1.3 Power Amplifier, Model 22183

A newly designed Power Amplifier, Model 22183, was delivered to UBSO, the prescribed preinstallation tests were performed, and the unit was installed. The amplifier would not start under an appreciable load; however, the unit would carry a load of up to 750 watts if the unit was started under a small load and the load was gradually increased. The amplifier was operated under a load of about 300 watts, but frequent intermittent shut-downs were

experienced. The unit was returned to Garland for inspection and repair.

Temporarily, a 60-watt Power Amplifier, Model 9231, was installed (see figure 2) as an emergency measure and to provide a back-up system for possible addition of Develocorders and Helicorders. The magnetic-tape recorders are operated on unregulated line power.

After inspection in Garland, the Model 22183 amplifier was modified by increasing the drive to the silicon control-rectifiers. Also, a short between one of the fan mounting screws and a heat-sink fin, that resulted from shipping damage was repaired. The unit was returned to UBSO and reinstalled on 31 August.

Evaluation of the Model 22183 power amplifier was again interrupted due to component failures. These failures occurred while the timing system was being adjusted. The power amplifier was returned to our Garland laboratory. Environmental tests in Garland indicated malfunction of several components, and the short-circuit protection system required a slight modification. Laboratory tests indicated that after modification, the power amplifier was performing satisfactorily. The unit was reshipped to UBSO, late in October.

6.1.4 Telephone Link to Deep-Well Site

A permanent telephone link was routed to the deep-hole site using scrap sections of spiral-four cable. This was done to provide a reliable communications link between the central recording building and the deep-hole site. The cable was terminated at the vertical array PTA hut and jumpers were installed to both winches.

6.1.5 Gasoline-Powered Generator

A 6.3 KVA gasoline-powered generator was delivered to UBSO from the Large Aperture Seismic Array (LASA) Maintenance Center on 14 September. We had planned to use this generator in the UBSO system to supply standby power for charging the batteries during prolonged commercial power failures. The motor, however, is a hand-cranked unit and no provision has been made for automatic starting; consequently, the generator would be useful only if station personnel were present when a power failure occurred. At the present time, we do not plan to modify the motor for automatic starting.

6.1.6 New Program for Data Group 5052 (MAP I)

The printed circuit boards for the new program in the MAP I system was received and the boards were installed in MCF-1. The modified MCF-1 became operational on 20 October and will subsequently be designated MCF-4. On 24 October, MCF-2 program was removed and the old MCF-1 program was installed in its place to facilitate direct comparison of the new and old

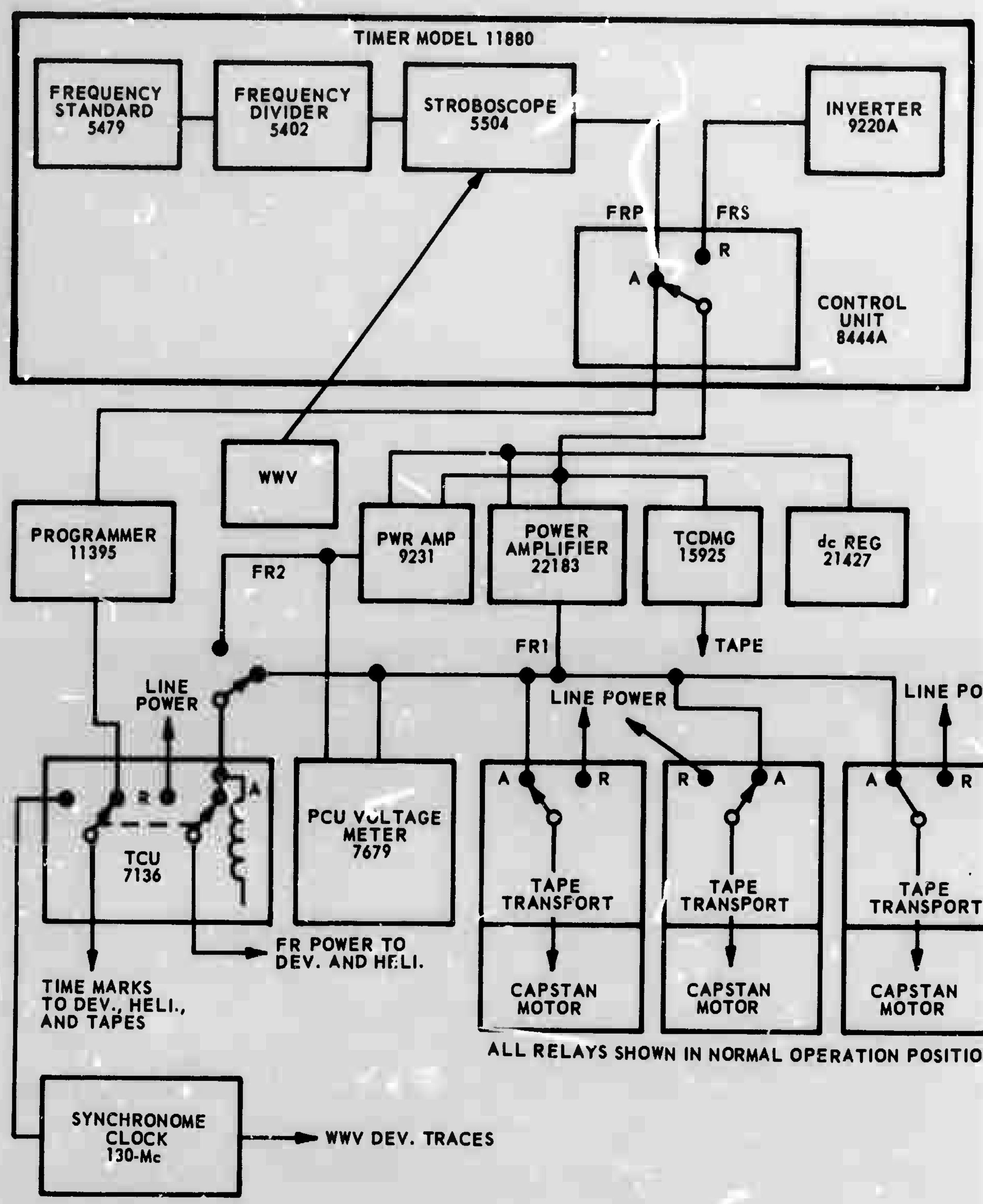


Figure 2. Block diagram of UBSO power system

G 18

MCF-1 programs. Figures 3 through 10 show these comparisons. Note that at times MCF-4 (the modified program) is little or no better than the old MCF-1. UBSO personnel forwarded pictures of all short-period seismograms illustrating the effectiveness of the MCF-4 program to the Project Officer.

6.2 ADDITIONAL INSTRUMENTATION AT UBSO

6.2.1 Six-Element Vertical Array

The first string of three seismometers of the six-element vertical array was installed in the Carter Oil Company, No. 6 Vernal (figure 11) near the end of the last reporting period. The top string of three seismometers of the vertical array was lowered into the deep hole early in this reporting period. The string was not set in the hole, however, because of a malfunction of the holelock motor of seismometer No. 4.

The string of seismometers was removed and the holelock motor on the No. 4 seismometer was repaired. The first and second jumpers were connected and reinstallation of the second string of seismometers was started. When the No. 4 seismometer was at a depth of about 1,000 feet, the connector between the first and second jumpers parted, allowing both the seismometer and a 1000-foot length of cable to drop into the hole. We thought it might be possible to clean the hole by raising the bottom string of seismometers. The string was raised about 80 feet, but the cable parted under a load of about 8,000 pounds, at a depth of between 3700 and 3800 feet. The cable parted at a point damaged by the falling seismometer. A fishing rig was contracted to move onto the hole, and fishing began on 7 August. All equipment was retrieved in eight trips, all in one day.

Repair of the seismometers and spooling of new cable onto the winch was started by 13 August. Reinstallation of the bottom string of seismometers was completed and test data were being recorded by 30 August. The top three seismometers were installed by 5 September. The elements are set in the hole as follows:

Seismometer	Depth
No. 6	3907 feet
No. 5	4901 feet
No. 4	5894 feet
No. 3	6910 feet
No. 2	7903 feet
No. 1	8895 feet

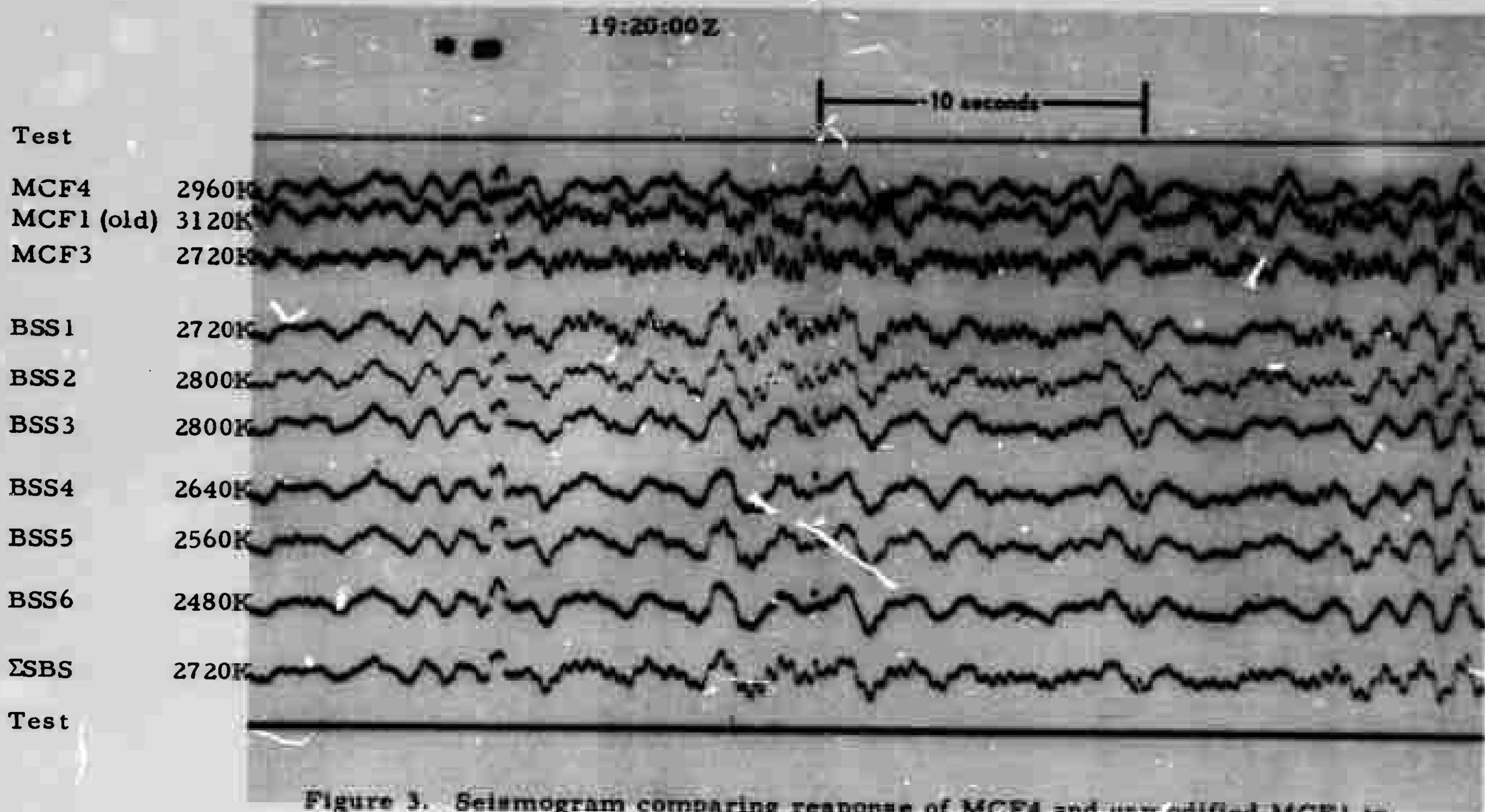


Figure 3. Seismogram comparing response of MCF4 and unmodified MCF1 to 3 cps noise at UBSO. (X10 enlargement of 16-millimeter film)

UBSO
01 Nov 66
Run 305
Data Group 5061

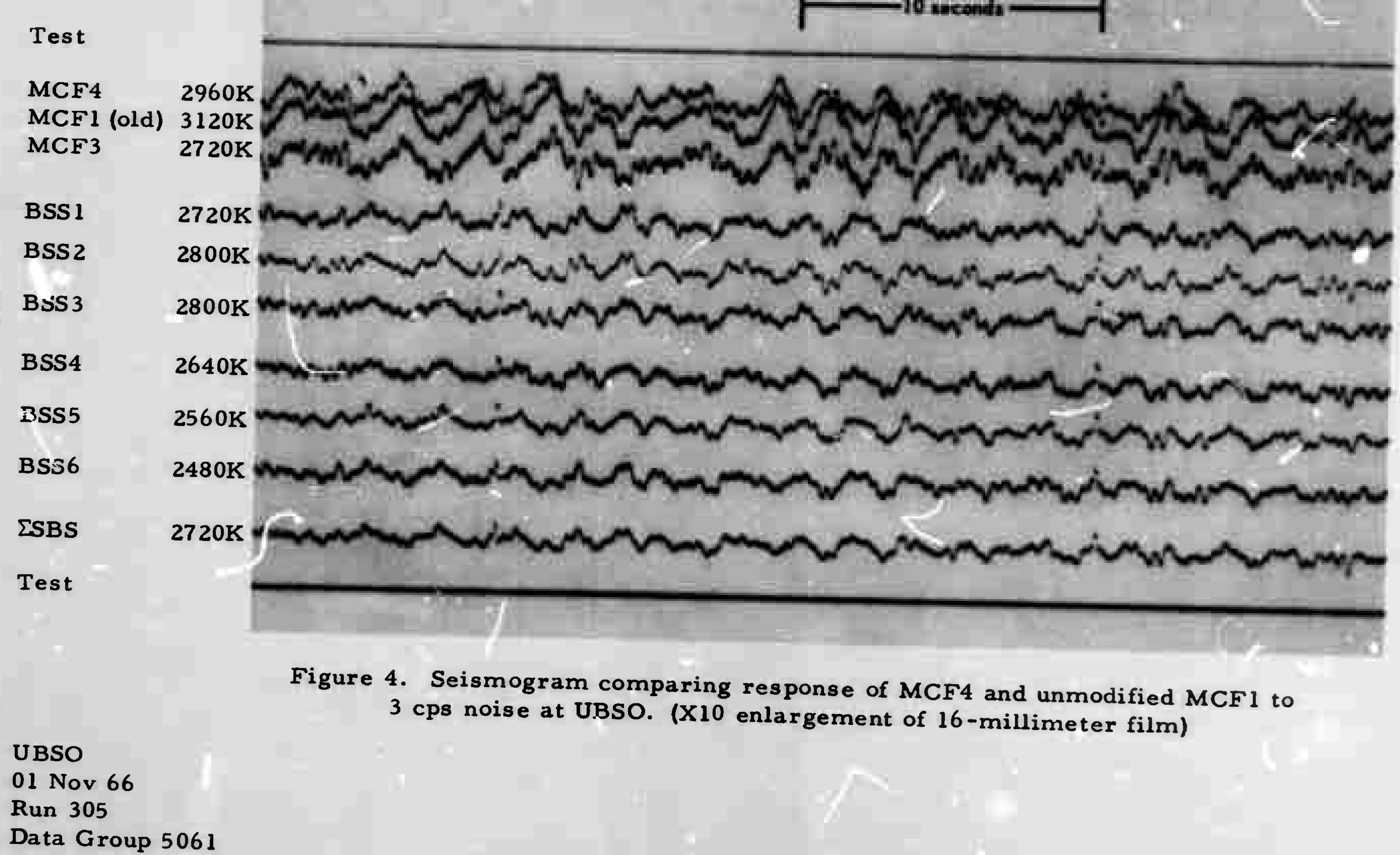


Figure 4. Seismogram comparing response of MCF4 and unmodified MCF1 to 3 cps noise at UBSO. (X10 enlargement of 16-millimeter film)

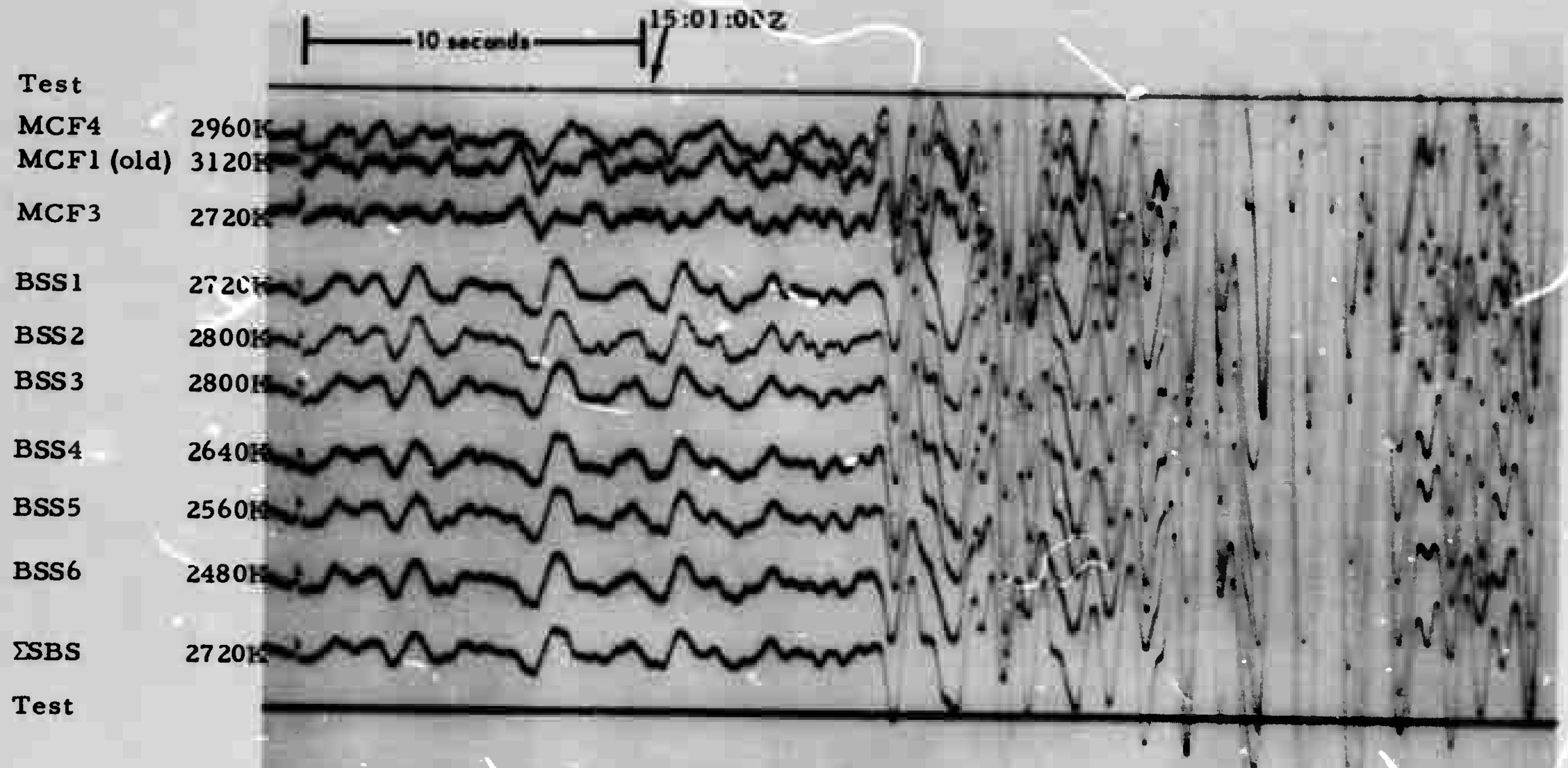


Figure 5. Seismogram comparing response of MCF4 and unmodified MCF1 of UBSO to teleseismic signal from unknown epicenter. (X10 enlargement of 16-millimeter film)

UBSO
01 Nov 66
Run 305
Data Group 5061

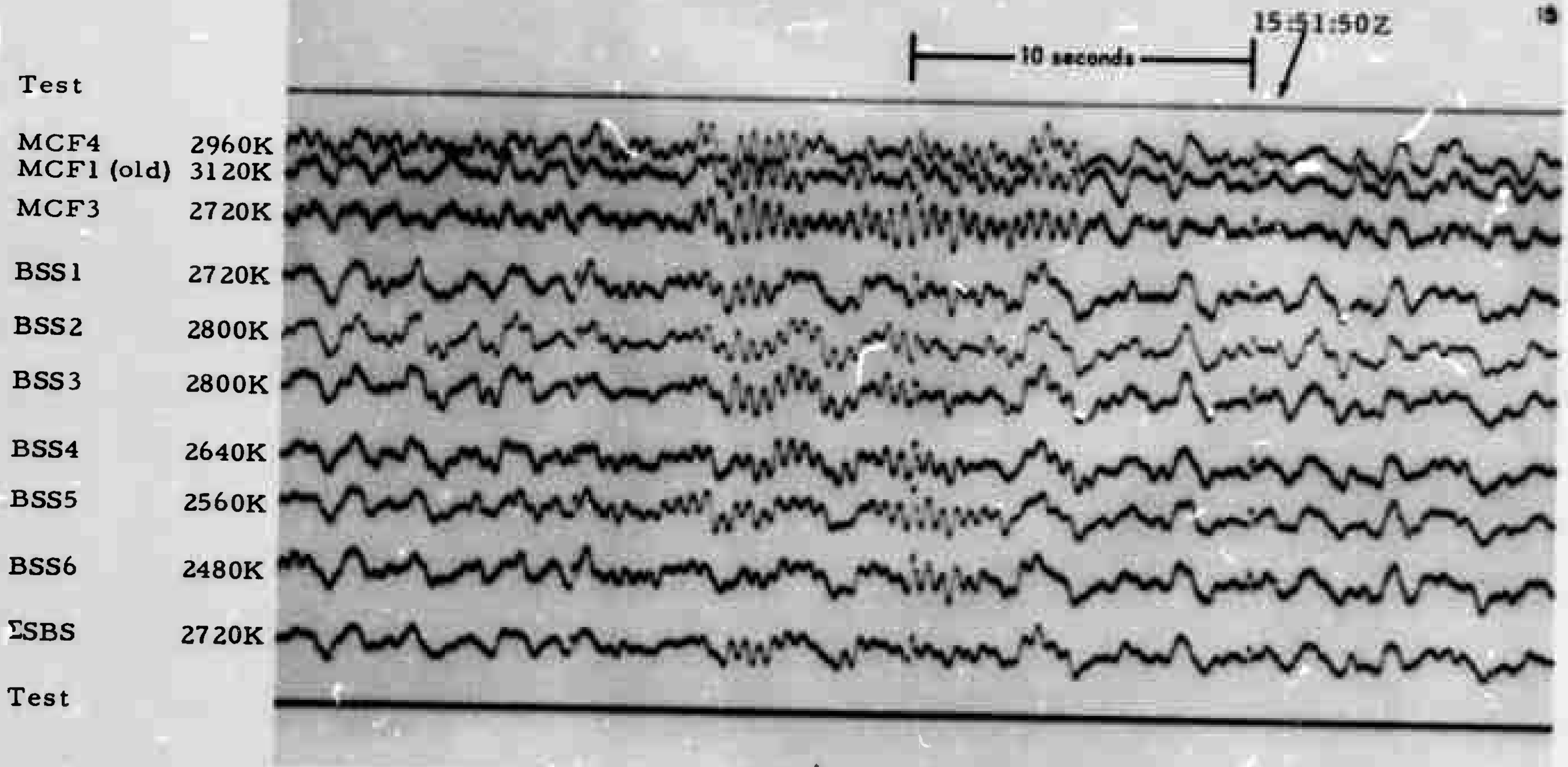


Figure 6. Seismogram comparing response of MCF4 and unmodified MCF1 to 3 cps noise at UBSO. (X10 enlargement of 16-millimeter film)

UBSO
01 Nov 66
Run 305
Data Group 5061

Test
MCF4 2960K
MCF1 (old) 3120K
MCF3 2720K
BSS1 2720K
BSS2 2800K
BSS3 2800K
BSS4 2640K
BSS5 2560K
BSS6 2480K
ΣSBS 2720K
Test

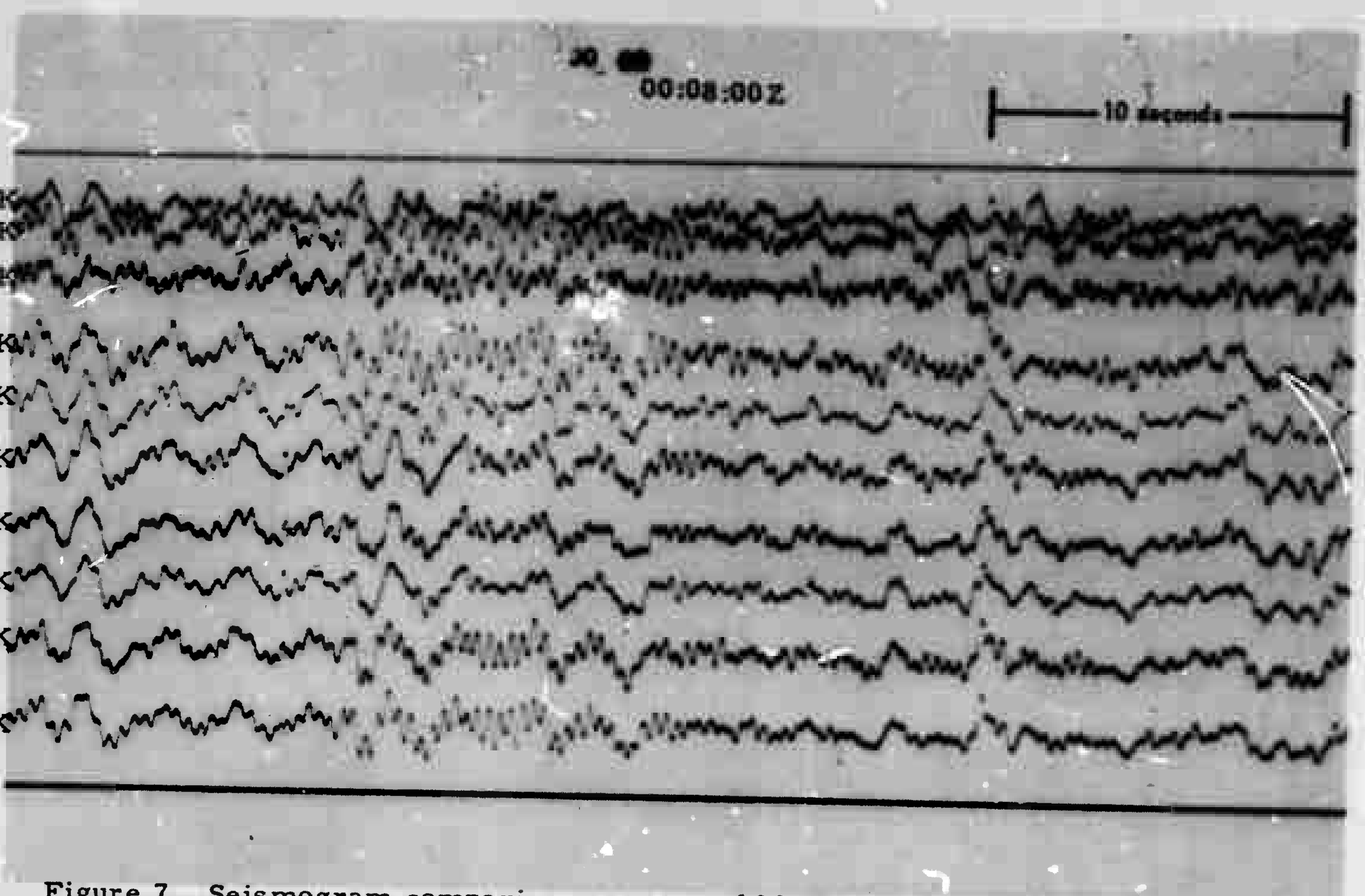
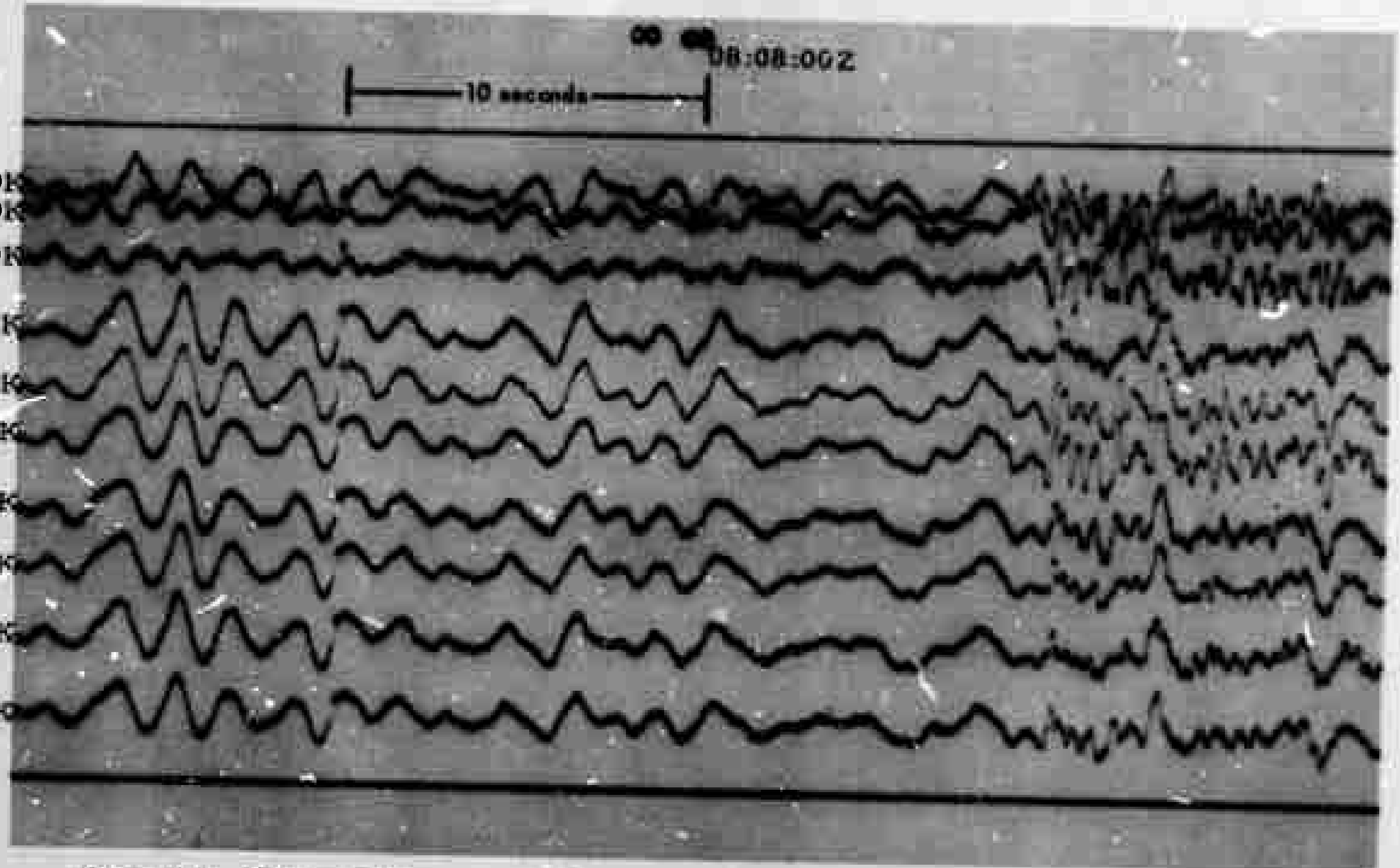


Figure 7. Seismogram comparing response of MCF4 and unmodified MCF1 to 3 cps noise at UBSO. (X10 enlargement of 16-millimeter film)

UBSO
01 Nov 66
Run 305
Data Group 5061



Test

MCF4 2960K
MCF1 (old) 3120K
MCF3 2720K
BSS1 2720K
BSS2 2800K
BSS3 2800K
BSS4 2640K
BSS5 2560K
BSS6 2480K
ΣSBS 2720K

Test

Figure 8. Seismogram comparing response of MCF4 and unmodified MCF1 to normal night background at UBSO and to a P-wave from a near-regional earthquake of unknown epicenter. (X10 enlargement of 16-millimeter film).

UBSO
01 Nov 66
Run 305
Data Group 5061

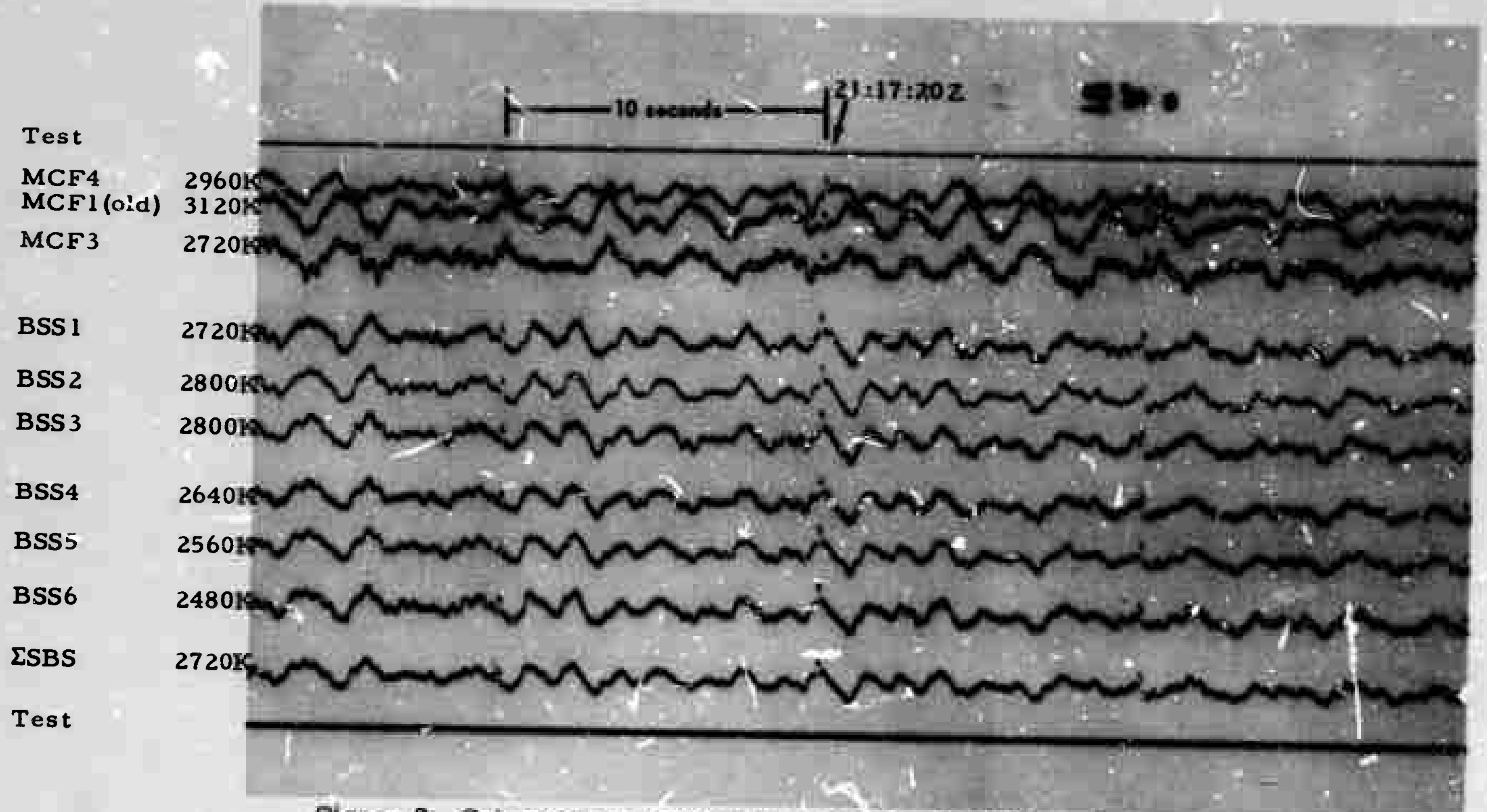


Figure 9. Seismogram comparing response of MCF4 and unmodified MCF1 to 3 cps noise at UBSO. (X10 enlargement of 16-millimeter film)

UBSO
01 Nov 66
Run 305
Data Group 5041

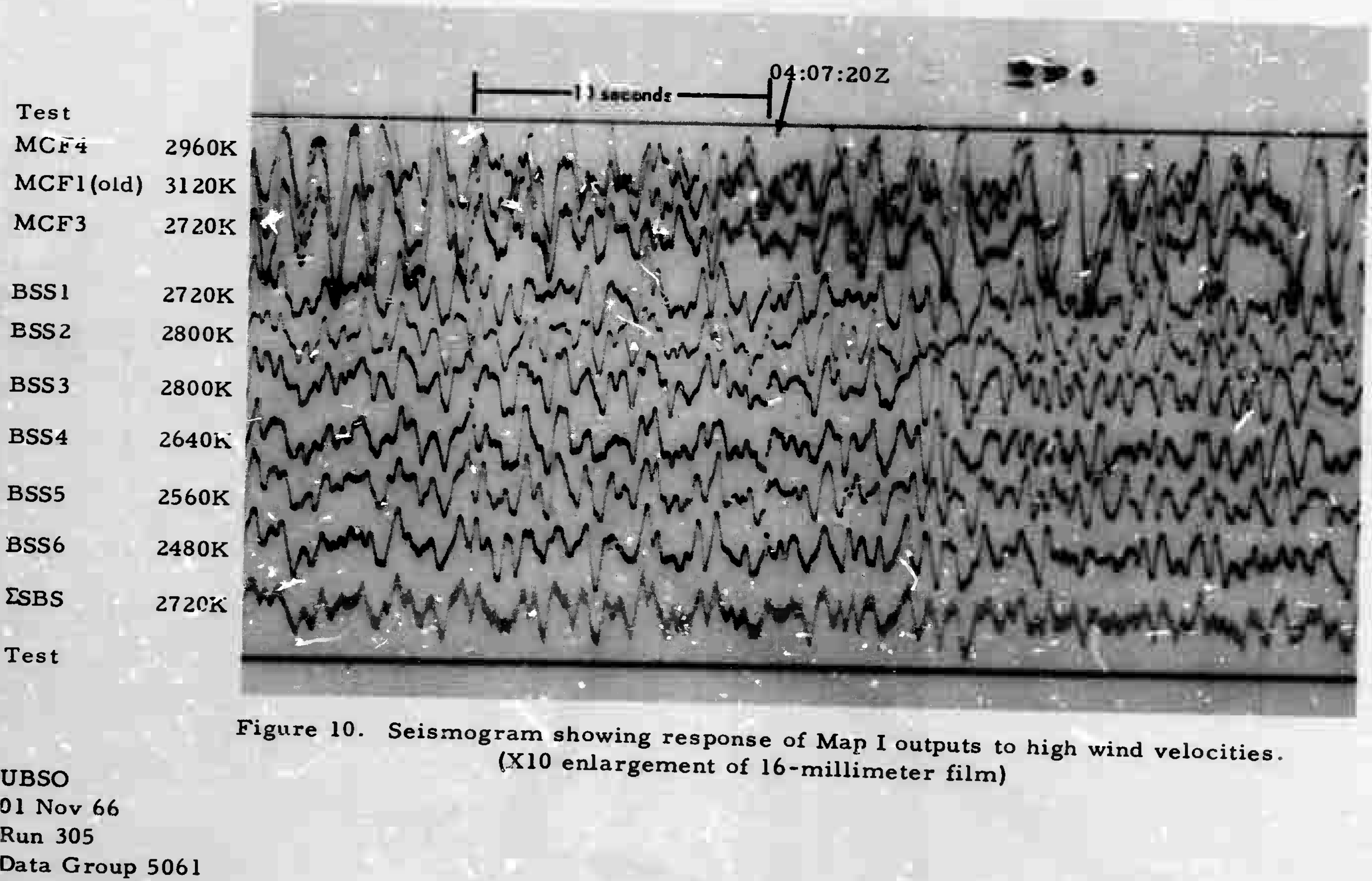


Figure 10. Seismogram showing response of Map I outputs to high wind velocities. (X10 enlargement of 16-millimeter film)

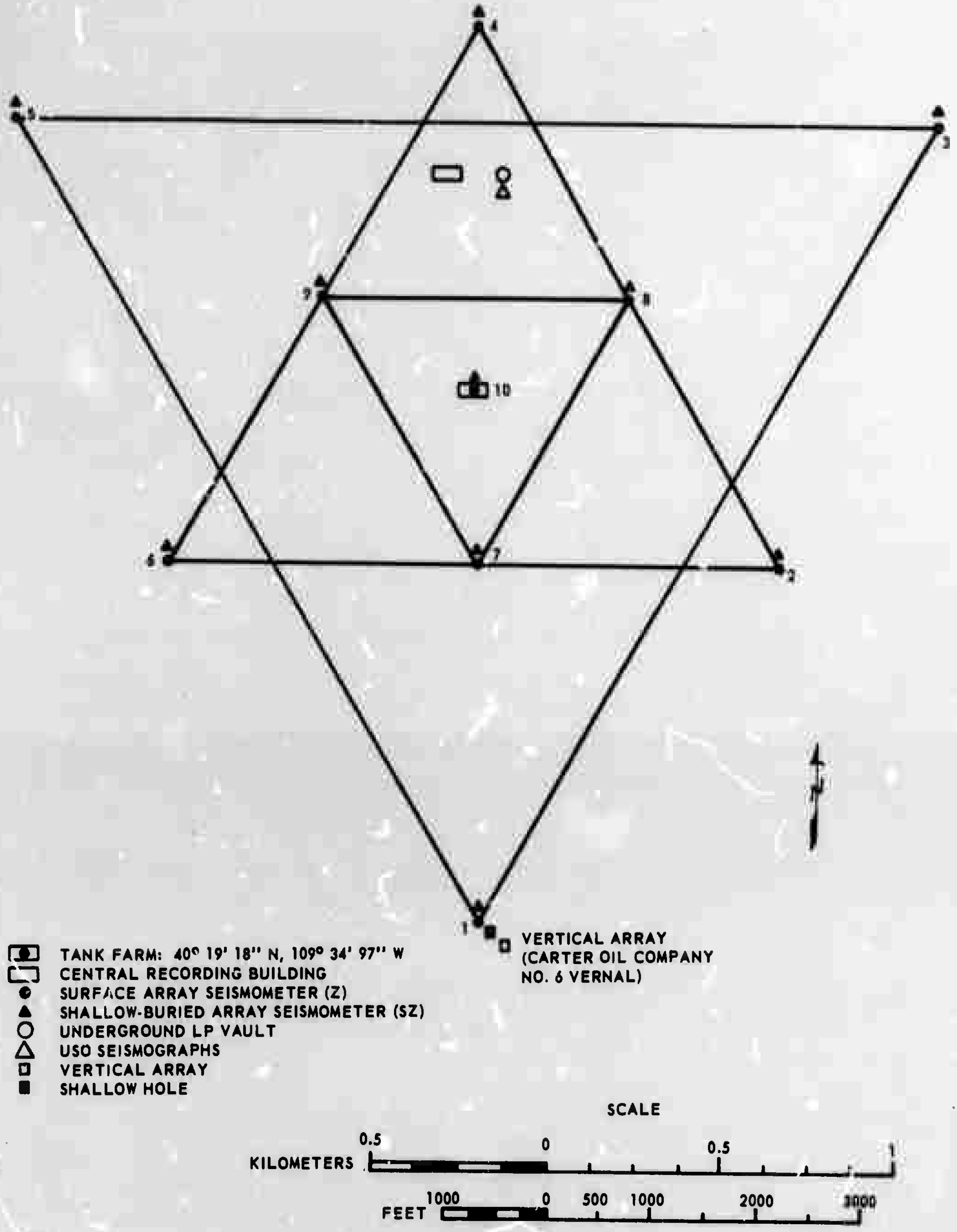


Figure 11. Location of seismographs at UBSO

G 1839

Some noise problems experienced immediately after completion of the installation of the seismometers were eliminated by moving the PTA's from the wellhead into the central recording building. By the end of the reporting period all seismograph channels were operating, the sensitivity of the Develocorder galvanometers had been equalized, and the seismograph frequency responses were being checked. Figures 12 through 15 show the response of vertical array seismographs to typical noise and signals.

6.2.2 Additional MAP Units

Data Group 5054 (MAP II) became operational early in October. MAP outputs of the shallow-buried and vertical arrays are included in this data group. Figures 16 through 21 show the response of MAP II to typical noise and signals at UBSO. Primary short-period data corresponding to the noise data shown in figures 17 and 18 are shown in figures 22 and 23. Vertical array seismograms of the earthquakes shown in figures 13 through 15 are shown in figures 19 through 21.

7. ANALYZE DATA

7.1 GENERAL

Effective 1 August, determinations of event arrival times, periods, and amplitudes for routine daily analysis are made from seismograms of the shallow-buried array.

7.2 REPORT EVENTS TO U. S. COAST AND GEODETIC SURVEY (USC&GS)

Analysts daily report the time of arrival, period and center-to-peak ground displacement of events recorded at UBSO to the Director of USC&GS in Washington, D. C. The number of events, by type, reported by UBSO during each month in this reporting period is shown in table 5. The total number of events recorded by the observatory, the number of epicenters determined by USC&GS and reported in the "Earthquake Data Report", and the percentage of the hypocenters in which UBSO data were utilized, are shown in table 6 for March through July 1966. Lists of more recent epicenters have not been completed by USC&GS.

7.3 DAILY ANALYSIS FOR MULTISTATION EARTHQUAKE BULLETIN

Data from UBSO are combined with data from BMSO, CPSO, TFSO, and WMSO and published in a monthly multistation earthquake bulletin. The

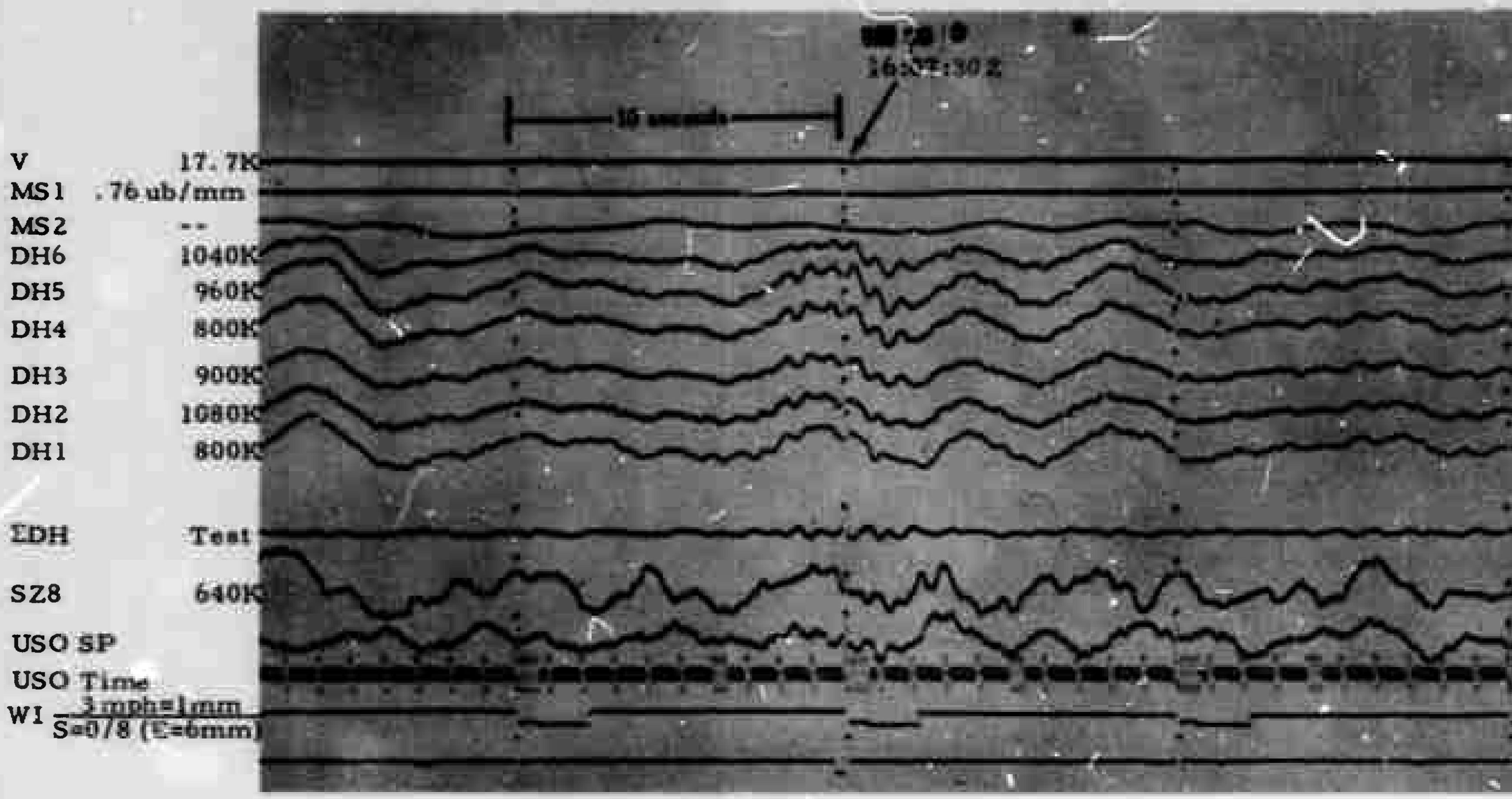


Figure 12. Short-period seismogram showing response of elements of vertical array to noise from traffic on highway near UBSO. (Compare with figures 17 and 22). (X10 enlargement of 16-millimeter film)

UBSO
07 Oct 66
Run 280
Data Group 5056

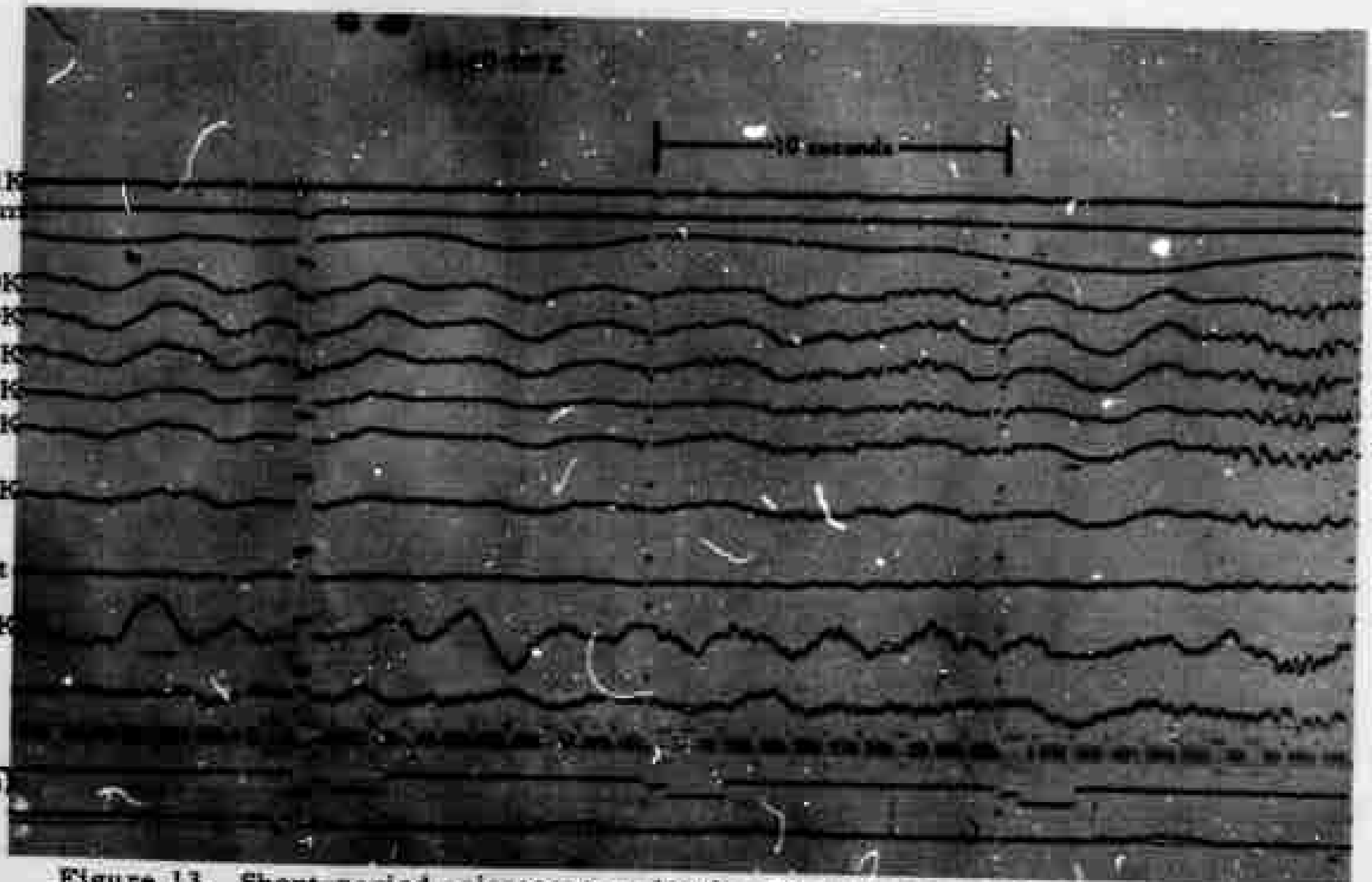


Figure 13. Short-period seismogram showing six-element vertical array at UBSO response to a small local event, epicenter unknown. (X10 enlargement of 16-millimeter film)

UBSO
09 Oct 66
Run 282
Data Group 5056

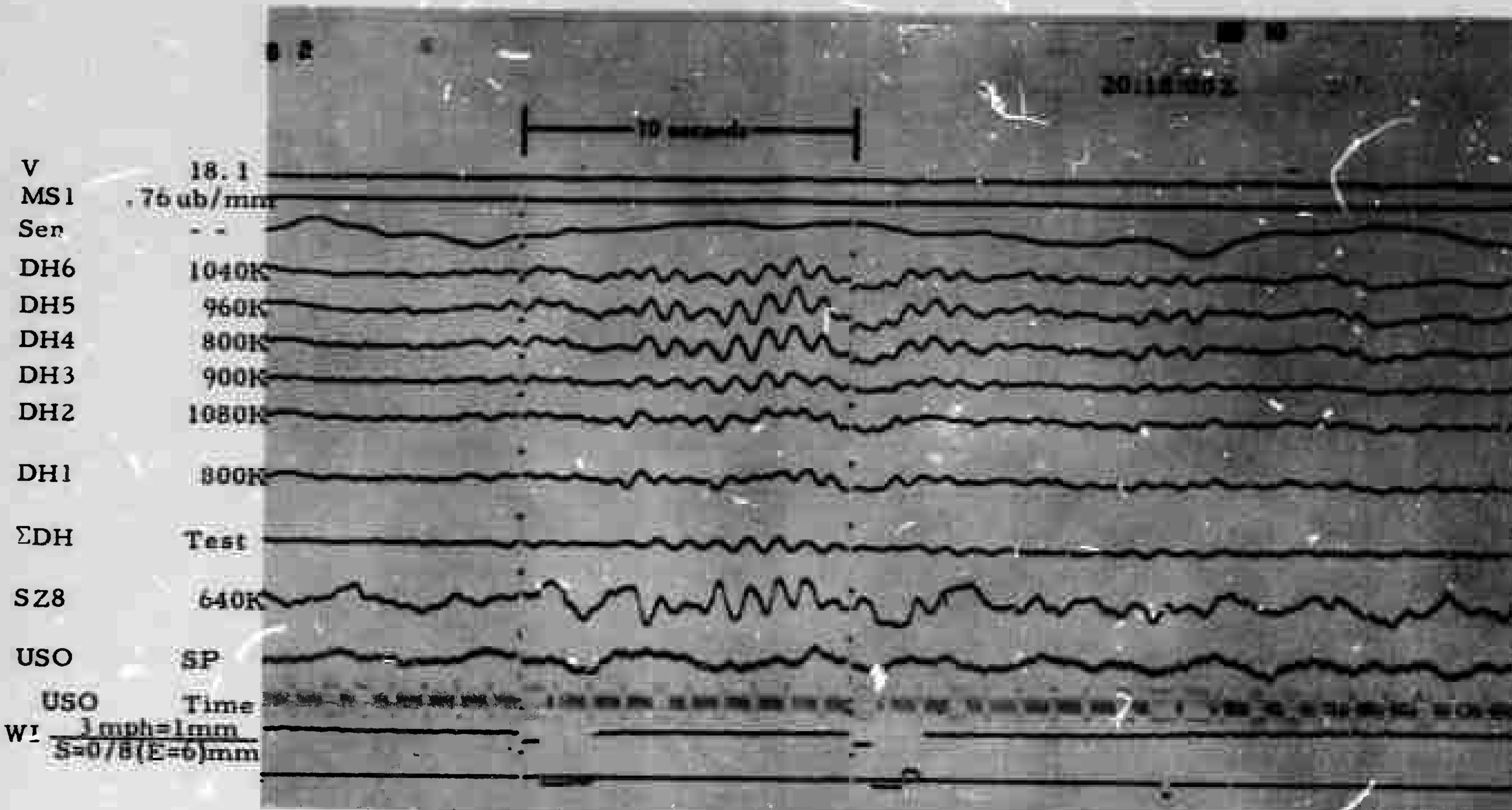


Figure 14. Short-period seismogram showing response of six-element vertical array to teleseismic signal, epicenter unknown. (X10 enlargement of 16-millimeter film)

UBSO
09 Oct 66
Run 282
Data Group 5056

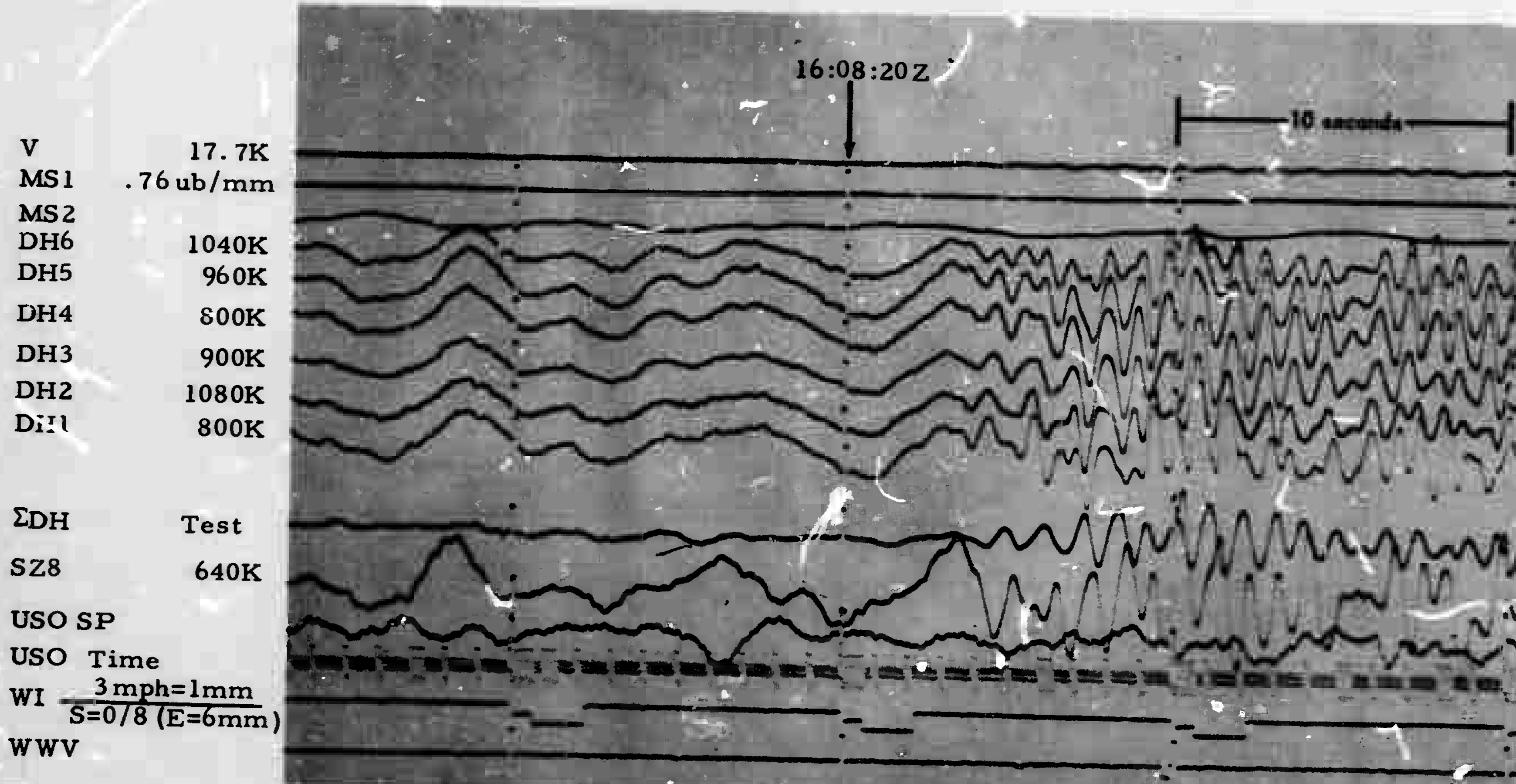


Figure 15. Short-period seismogram illustrating response of elements of vertical array at UBSO to teleseismic signal from unknown epicenter. (X10 enlargement of 16-millimeter film)

UBSO
07 Oct 66
Run 230
Data Group 5056

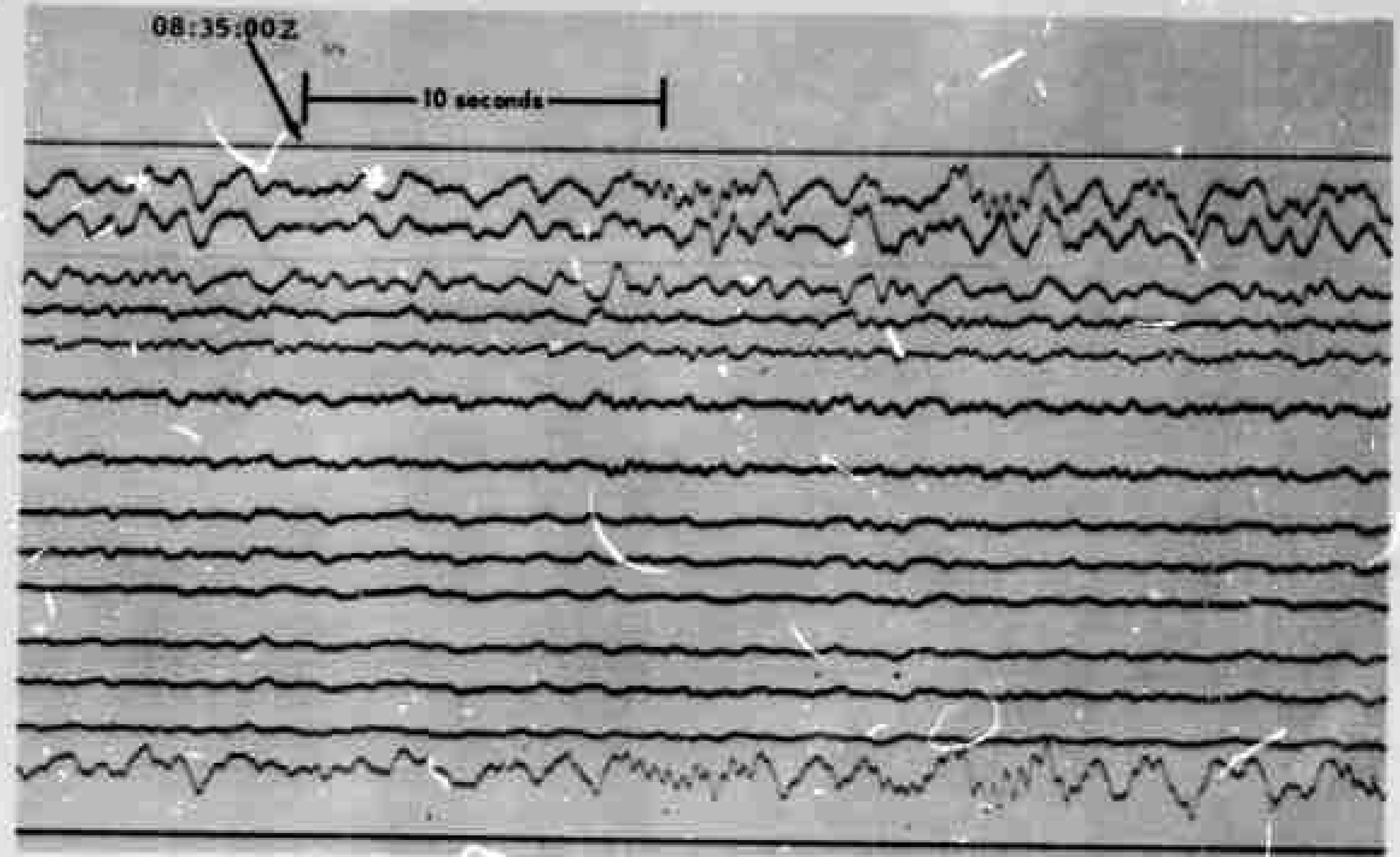


Figure 16. Short-period seismogram of typical background of Map II outputs. (X10 enlargement of 16-millimeter film)

UBSO
07 Oct 66
Run 280
Data Group 5054

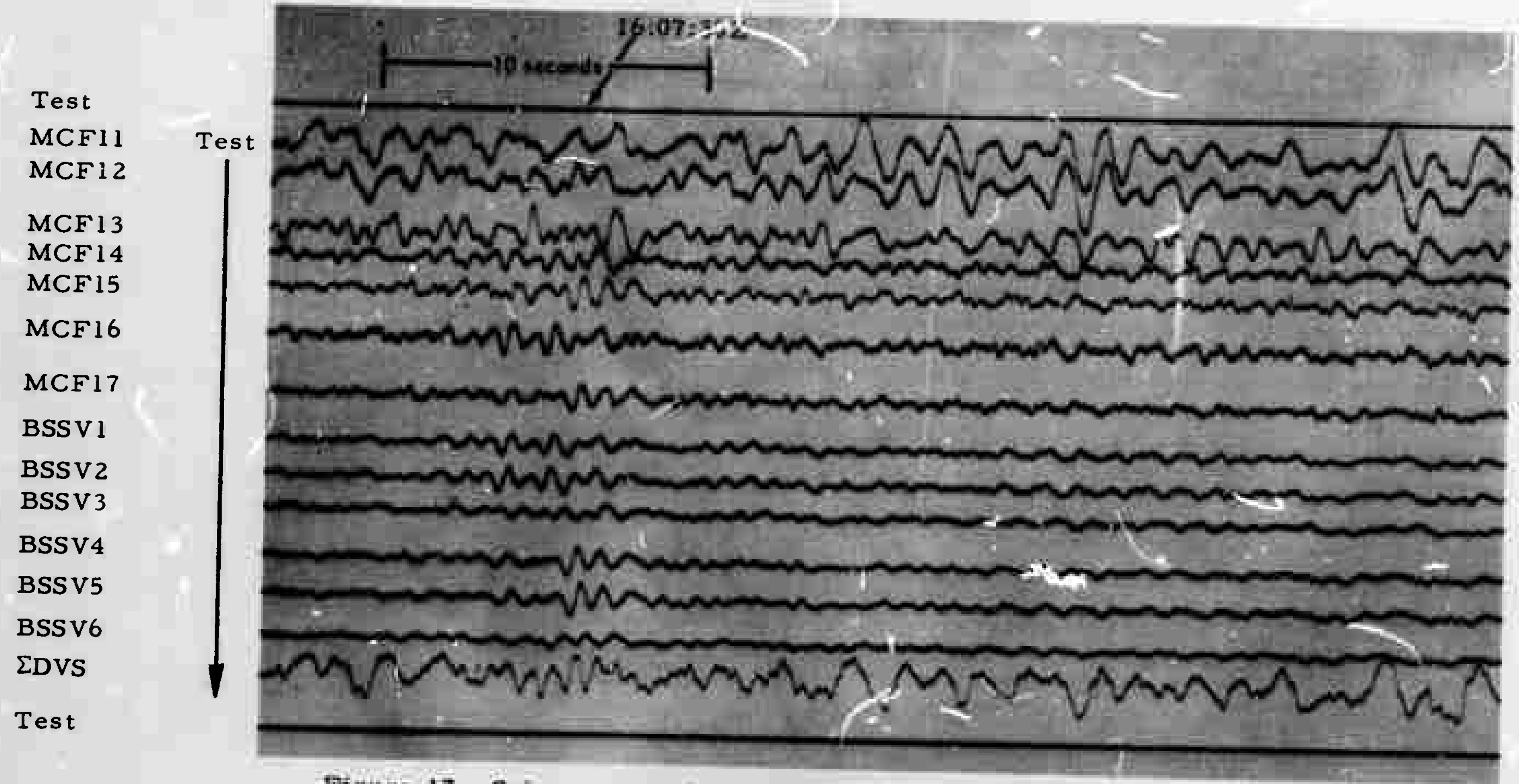


Figure 17. Seismogram showing response of multi-channel array processor to noise from traffic on highway near UBSO. (X10 enlargement of 16-millimeter film)

UBSO
07 Oct 66
Run 280
Data Group 5054

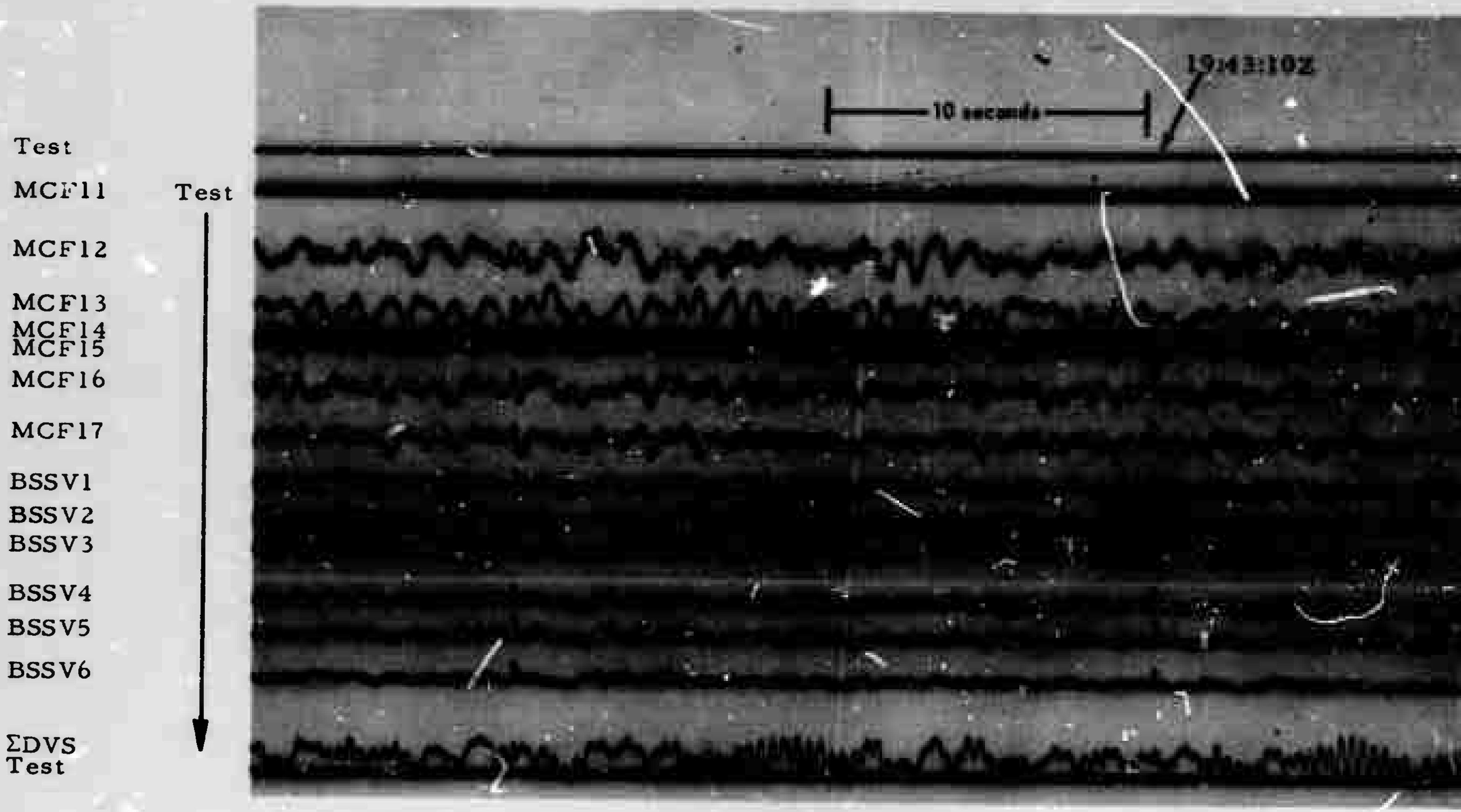


Figure 18. Seismograms showing response of multi-channel array processor II to cultural noise at UBSO. (Compare with figure 23.)(X10 enlargement of 16-millimeter film)

UBSO
01 Oct 66

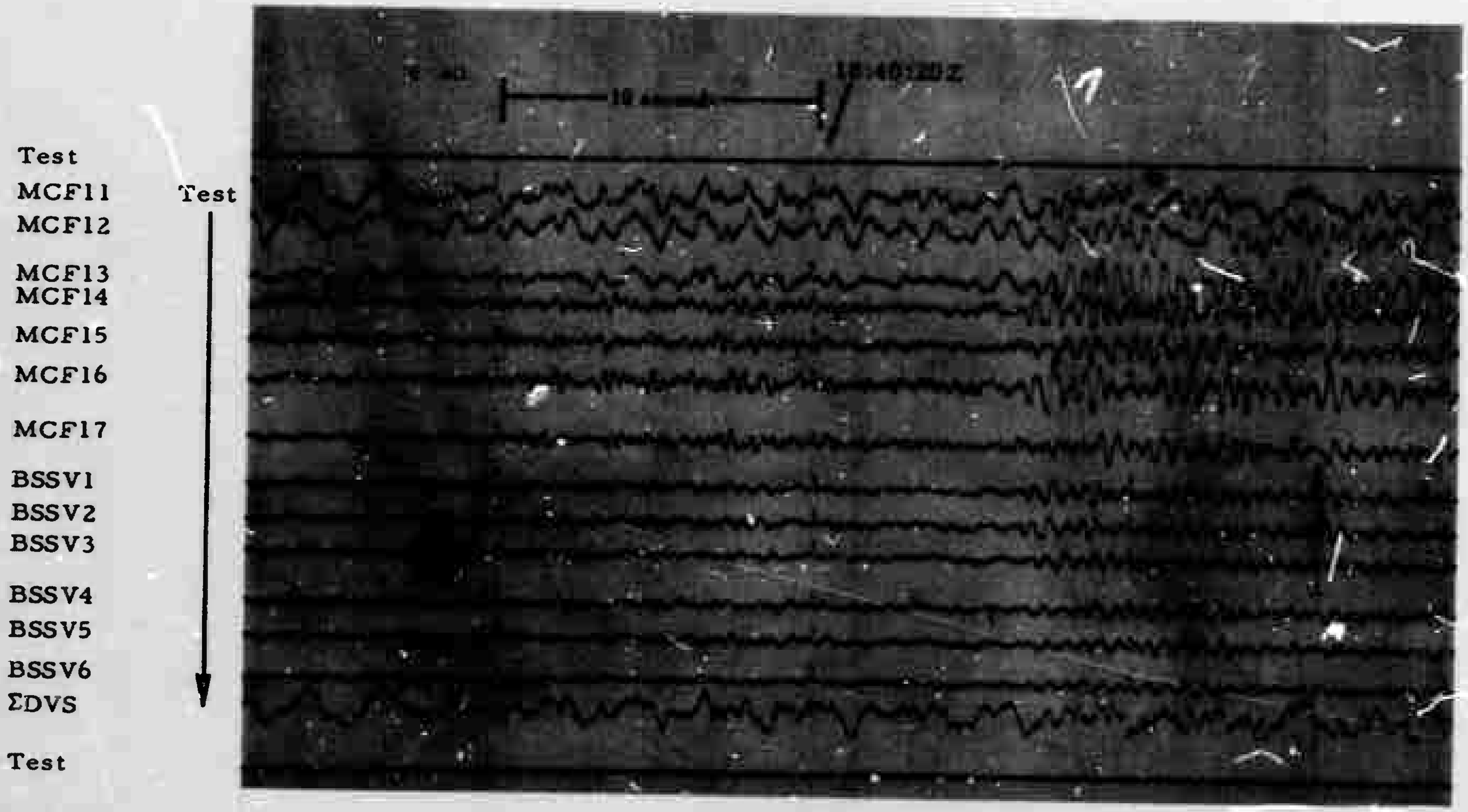


Figure 19. Seismogram showing response of multi-channel array processor II at UBSO to a local event, epicenter unknown. (X10 enlargement of 16-millimeter film)

UBSO
09 Oct 66
Run 282
Data Group 5054

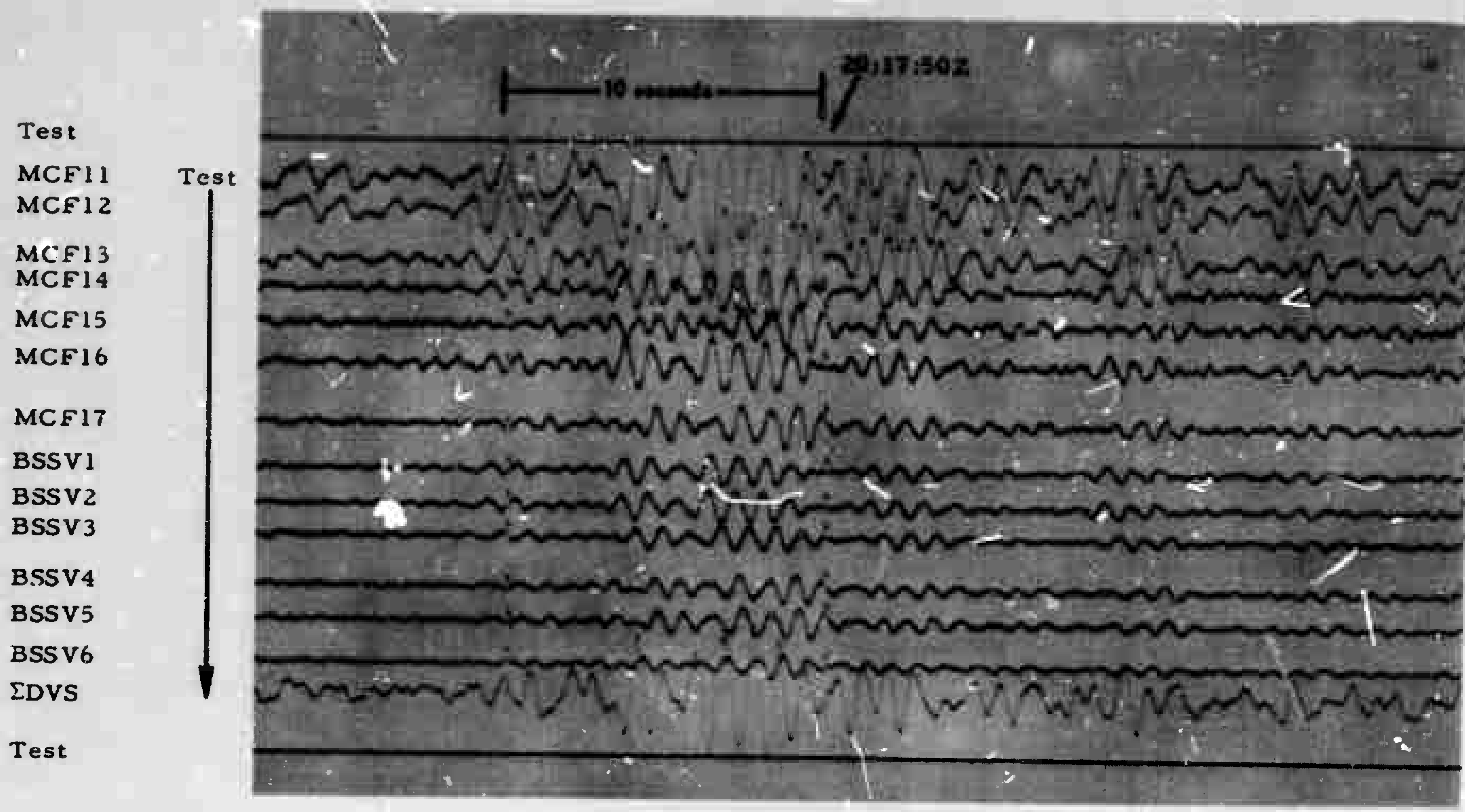


Figure 20. Seismogram showing response of multi-channel array processor II at UBSO to teleseismic signal, epicenter unknown. (X10 enlargement of 16-millimeter film)

UBSO
09 Oct 66

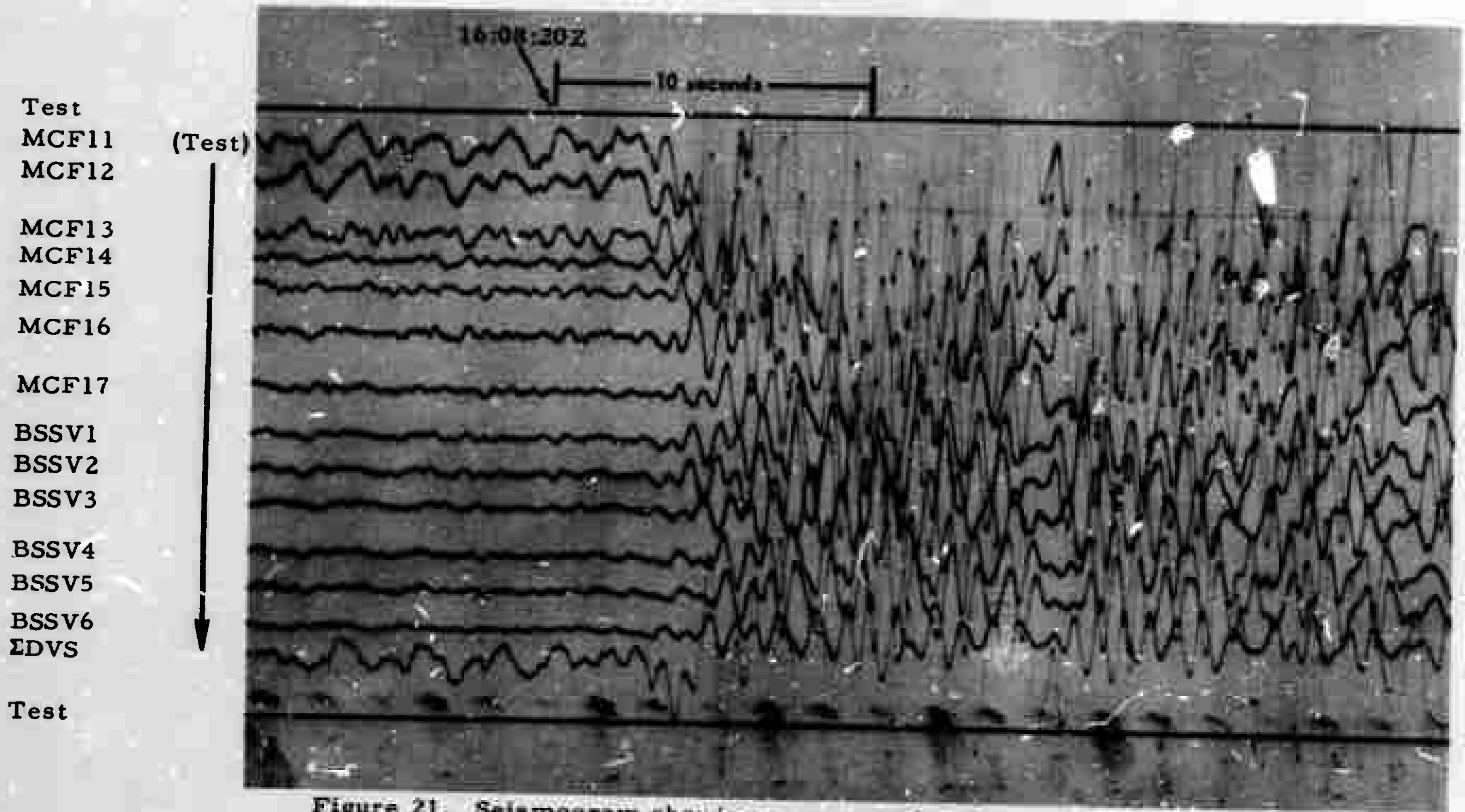


Figure 21. Seismogram showing response of multi-channel array processor at UBSO to a teleseismic signal, epicenter unknown. (X10 enlargement of 16-millimeter film)

UBSO
07 Oct 66
Run 280
Data Group 5054

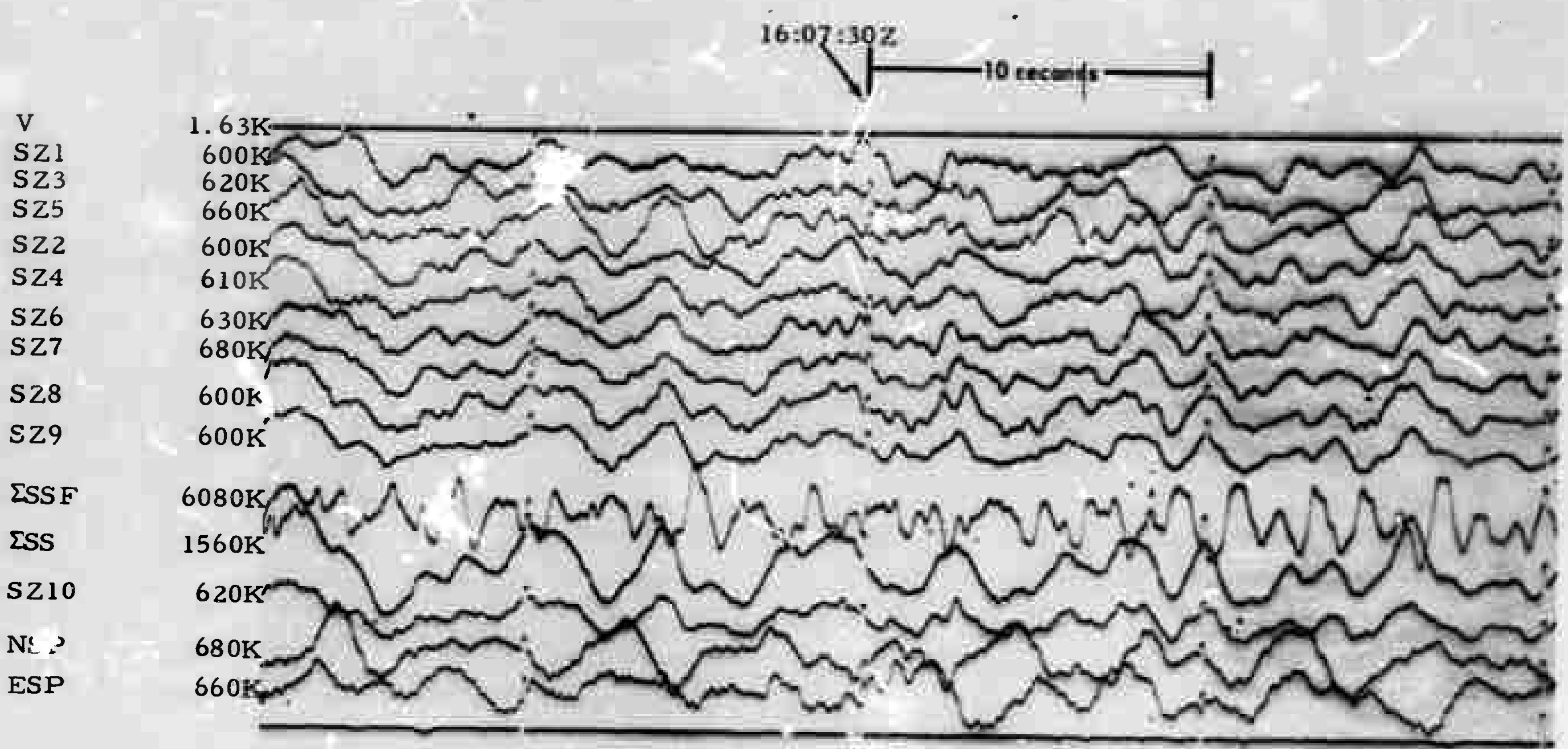


Figure 22. Short-period seismogram showing response of shallow-buried array to noise from traffic on highway near UBSO. (X10 enlargement of 16-millimeter film)

UBSO
07 Oct 66
Run 280
Data Group 5044

V	0.82K
SZ1	620K
SZ3	620K
SZ5	650K
SZ2	590K
SZ4	620K
SZ6	640K
SZ7	580K
SZ8	640K
SZ9	600K
ΣSSF	6160K
ΣSS	1540K
SZ10	600K
NSP	610K
ESP	550K
WWV	

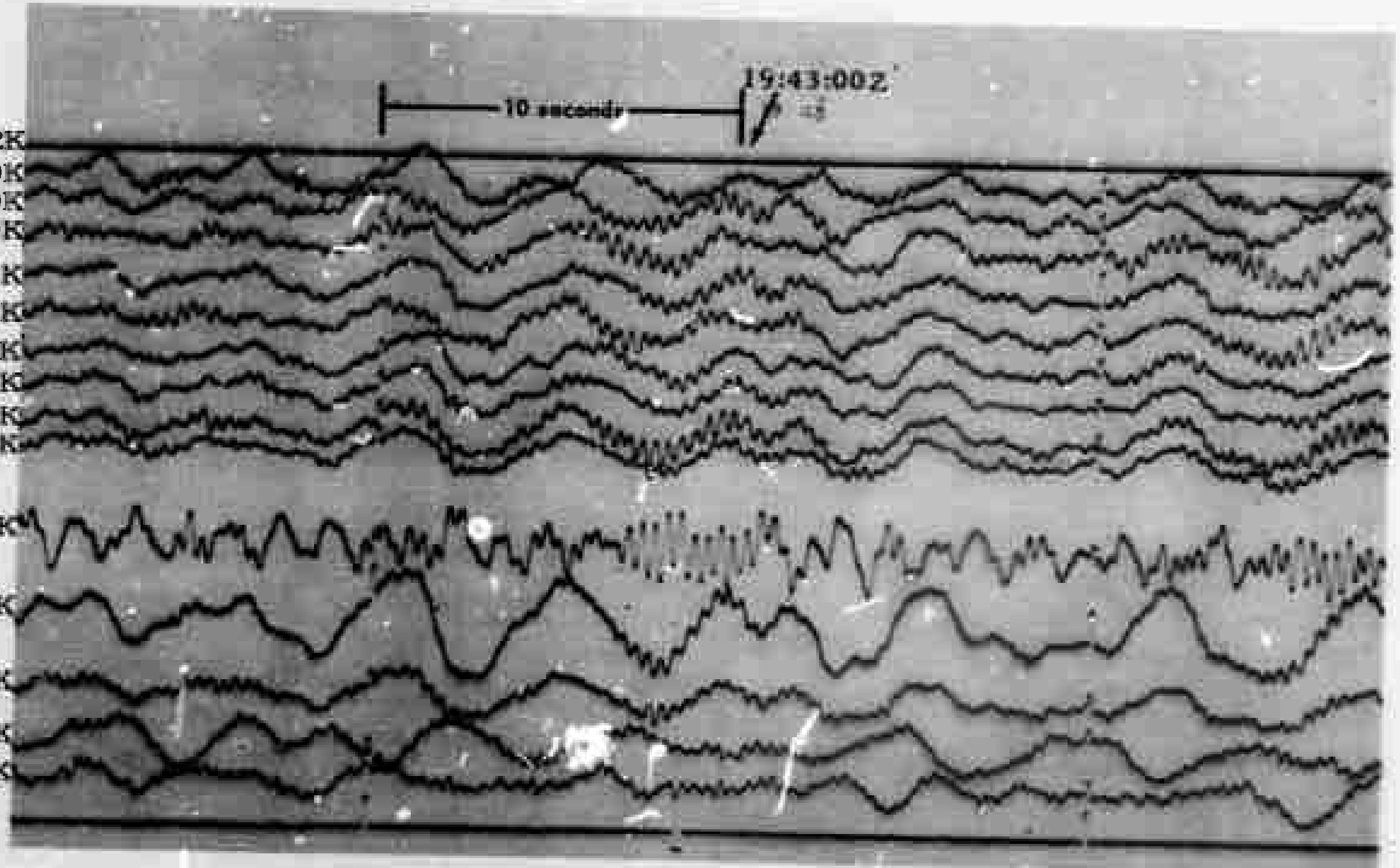


Figure 23. Short-period seismogram showing response of the shallow-buried array at UBSO, to cultural noise. (X10 enlargement of 16-millimeter film)

UBSO
01 Oct 66
Run 274
Data Group 5044

Table 5. Number of earthquakes reported to USC&GS by UBSO during August, September and October 1966

August 1966					September 1966					October 1966				
L	N	R	T	Total	L	N	R	T	Total	L	N	R	T	Total
31	817	41	1319	2208	46	668	65	1156	1935	70	541	47	1303	1961

Table 6. Percentage of hypocenters reported in the USC&GS "Earthquake Data Report" for which UBSO data were used

Date	Events reported by UBSO	Hypocenters reported by USC&GS	Percent of USC&GS events utilizing UBSO data
March 1966	1274	432	69.0
April 1966	1326	401	82.5
May 1966	1246	442	71.0
June 1966	1467	446	65.0
July 1966	1597	338	79.1

bulletins for March, April, and May 1966 were published during this reporting period.

The raw data for June and July were transcribed onto digital magnetic tape and sent to SDL for processing. Errors in June input data were discovered during processing of the data for Automated Bulletin Process (ABP). These errors were corrected and the data have been resubmitted for ABP processing.

The check program for raw data was revised to flag errors of the type occurring in the June data, and all subsequent raw data will be checked for these error types.

Data for August and September have been transcribed onto tape, and will be checked and sent to SDL for processing. Keypunching of October raw data is about 50 percent complete.

7.4 CONTINUE NOISE SURVEY

Measurements of ambient noise in the 0.4 to 1.4 second period range are made daily at UBSO. Data are processed in Garland, and monthly cumulative probability curves of trace amplitude and ground displacement are published. Noise data are reported from the Z10, SZ10, ΣT, SΣT, ΣTF, and SΣTF seismograms. Curves for the months of June, July and August were sent to the Project Officer during this reporting period.

8. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS

8.1 MONITOR OF SANDIA'S USO

We began recording the outputs of the Sandia Unmanned Seismological Observatory (USO) seismographs late in the last reporting period; however, excessive amounts of 60 cps and 10 cps noise were noted on the USO seismograms. Sandia was notified, and they requested that we install a 10 microfarad capacitor across the output lines. Installation of the capacitor, however, afforded no noticable improvement in the seismograms. Messrs. Kreitter and Linn, Sandia representatives, visited UBSO on 15 through 17 August to investigate methods of eliminating the noise.

The noise occurring at 60 cps, generated within the USO, was reduced by the Sandia personnel; however, 5 to 6 volt ac potential between the USO ground and the observatory ground accounts for the 60 cps noise now

observed on the Develocorder traces. While this noise does not interfere with UBSO's monitoring assignment, the seismograms are useless for conventional measurements.

The cause of the 10 cps noise on the film seismograms has not yet been determined. Based on a comparison of the frequency responses, relative operating magnifications, and seismograms of the short-period USO seismographs and the shallow-hole, high-frequency seismograph previously operated at UBSO, it is our opinion that a part of this 10 cps noise is not seismic noise but is generated in the USO system.

When Sandia personnel were working with the USO time encoder during their August visit, the year code was inadvertently changed to 1967. Sandia was notified of this condition.

On 8 September, Sandia representatives visited UBSO to inspect the USO and to troubleshoot malfunctions reported to them. They left the observatory on 9 September. Subsequently, we discovered that no data were being supplied to either the short-period vertical or north-south outputs and that the USO time code was in error by 12 hours. No automatic calibration pulses were put on USO data beginning on 26 September. Sandia was notified of these problems, and on 17 October, Sandia representatives arrived at UBSO. The magnetic-tape recorder which was not operating was replaced, other minor problems were corrected, and all USO seismographs appeared to be functioning properly at the end of the reporting period.

Special recordings of the USO seismographs were made on 24 and 25 August at the request of the Project Officer. These seismograms were from the USO long-period vertical, short-period vertical, and short-period east-west seismographs.

Location of the USO seismographs is shown in figure 11.

8.2 COOPERATE WITH USC&GS

In addition to the routine messages, UBSO cooperates with the USC&GS in providing information on specified events. One example of this is the reporting of aftershocks of the Utah event of 16 August. All analysis data on this series of shocks were sent to Mr. Ken Bayer of the USC&GS in Rockville, Maryland.

UBSO recorded and reported a total of 399 events of this swarm from 16 through 25 August.

8.3 UNIVERSITY OF UTAH

UBSO supplied data to the University of Utah concerning the earthquakes in southwestern Utah and in other areas, including the large earthquake in the Lake Tahoe area on 12 September.

8.4 VISTORS

Several representatives from Sandia Corporation were vistors at UBSO during this reporting period.

Messrs. Ariel Michie and Edgar M. Hays, Utah State Health Department, visited UBSO on 20 September to sample the Develocorder slime build-up for chemical analysis.

A professor and eight students from Rangely College visited the observatory in October.

9. REPORTS

The UBSO Quarterly Report No. 1, Technical Report No. 66-84, was mailed to the Project Officer on 25 August.

APPENDIX 1 to TECHNICAL REPORT NO. 66-102

STATEMENT OF WORK TO BE DONE

AFTAC Project Authorization No. VELA T/6705

EXHIBIT "A"

STATEMENT OF WORK TO BE DONE

AFTAC Project Authorization No. VELA T/6705/S/ASD (32)

1. Tasks: 8 February 1966

a. Operation:

(1) Continue operation of the Uinta Basin Seismological Observatory (UBSO), normally recording data continuously.

(2) Evaluate the seismic data to determine optimum operational characteristics and make changes in the operating parameters as may be required to provide the most effective observatory possible. Addition and modification of instrumentation are within the scope of work. However, such instrument modifications and additions, data evaluation, and major parameter changes are subject to the prior approval of AFTAC.

(3) Conduct daily analysis of seismic data at the observatory and transmit daily seismic reports to the US Coast and Geodetic Survey, Wash DC 20230, using the established report format and detailed instructions.

(4) Record the results of daily analysis on magnetic tape in a format compatible with the automated bulletin program used by the Seismic Data Laboratory (SDL) in their preparation of the seismological bulletin of the VELA-UNIFORM seismological observatories. The format should be established by coordination with SDL through AFTAC. The schedule of routine shipments of these prepared magnetic tapes to SDL will be established by AFTAC.

(5) Establish quality control procedures and conduct quality control, as necessary, to assure the recording of high quality data on both magnetic tape and film. Past experience indicated that quality control review of one magnetic tape per magnetic tape recorder at the observatory each week is satisfactory unless quality control tolerances have been exceeded and the necessity of additional quality control arises. Quality control of magnetic tape should include, but need not necessarily be limited to, the following items:

(a) Completeness and accuracy of operation logs.

(b) Accuracy of observatory measurements of system noise and equivalent ground motion.

(c) Quality and completeness of voice comments.

(d) Examination of all calibrations to assure that clipping does not occur.

(e) Determination of relative phase shift on all array seismographs.

(f) Measurement of DC unbalance.

(g) Presence and accuracy of tape calibration and alignment.

(h) Check of uncompensated noise on each channel.

(i) Check of uncompensated signal-to-noise of channel 7.

(j) Check of general strength and quality of timing data derived from National Bureau of Standards Station WWV.

(k) Check of time pulse modulated 60 cps on channel 14 for adequate signal level and for presence of time pulses.

(l) Check of synchronization of digital time encoder with WWV.

(6) Provide observatory facilities, accompanying technical assistance by observatory personnel, and seismological data to requesting organizations and individuals after approval by AFTAC.

(7) Maintain, repair, protect, and preserve the facilities of the seismological observatory in good physical condition in accordance with sound industrial practice.

b. Instrument Evaluation: After approval by AFTAC, evaluate the performance characteristics of experimental or off-the-shelf equipment offering potential improvement in the performance of observatory seismograph systems. Operation and test of such instrumentation under field conditions should normally be preceded by laboratory test and evaluation.

c. Special Investigations: Conduct research investigations as approved or requested by AFTAC to obtain fundamental information which will lead to improvements in the detection capability of UBSO. These programs should take advantage of geological, meteorological, and seismological conditions at UBSO. The following special studies should be accomplished.

(1) Long term evaluation of the multiple array processor units.

(2) Installation and evaluation of a vertical array.

(3) Evaluation of the long-period vault.

(4) Provide technical assistance and monitor an unattended seismological observatory to be installed at UBSO in June 1967.

Research might pursue investigations in, but is not necessarily limited to, the following areas of interest: microseismic noise, signal characteristics, data presentation, detection threshold, and array design (surface and shallow borehole). Prior to commencing any research

investigation, AFTAC approval of the proposed investigation and of a comprehensive program outline of the intended research must be obtained.

2. Approval by AFTAC will normally be provided through the project officer.

3. **Reports**: Provide reports in accordance with the Data requirements outlined in DD Form 1423 and attachment 1 thereto.

unclassified
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DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) TELEDYNE INDUSTRIES GEOTECH DIVISION Garland, Texas 75040	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

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Quarterly Report No. 2, Project VT/6705, 1 August through 31 October 1966

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Quarterly Report No. 2, Project VT/6705, 1 August through 31 October 1966

5. AUTHOR(S) (Last name, first name, initial)

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6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS

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d. ARPA Program Code No. 6F10	

10. AVAILABILITY/LIMITATION NOTICES

This document is subject to special export controls and each transmittal to foreign governments or foreign national may be made only with prior approval of the Chief of AFTAC.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Advanced Research Projects Agency Nuclear Test Detection Office Washington, D. C.

13. ABSTRACT

This report describes the operation of the Uinta Basin Seismological Observatory from 1 August through 31 October 1966. Modifications and additions to the observatory instrumentation are described, and tests to improve the operation of the observatory are reported. Also discussed is the status of special investigations designed to evaluate and improve the detection capability of the observatory.

DD FORM 1 JAN 64 1473

unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Unattended Seismological Observatory						
Vertical Array						
Multi-Channel Array Processor						
Seismograph Operating Parameters						

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